

**DESIGN FOR BEHAVIOR CHANGE: EVALUATING THE EFFECT  
OF MOTIVATIONAL DESIGN STRATEGIES TO SUPPORT  
PHYSICAL ACTIVITY AMONG OLDER ADULTS**

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PHYSICAL ACTIVITY AMONG OLDER ADULTS**

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To my mother and grandmother

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## SUMMARY

According to the National Health Interview Study, only 15.3% of older adults met the federal physical activity guidelines for aerobic and muscle-training activities in 2016 (Clarke et al., 2017), despite the known benefits that are associated with an active lifestyle (e.g. improved physical and cognitive functioning). Mobile health technology interventions such as smartphone applications (apps), mobile exertion games, and activity trackers have the potential to enhance the frequency and approach to physical activity among sedentary older adults. Despite their potential to increase and sustain physical activity and exercise, reports suggest that many of these technologies see low usage and early abandonment, often attributed to factors such as lack of motivational affordance in system features, poor usability, or no consideration of accessibility. Low usage and premature abandonment of health technologies prevents that actualization of potential health benefits and thus it is important for researchers and designers to design these technologies such that appropriate use is sustained.

One approach to creating technologies that effectively address health-related behaviors is design for behavior change as implemented through persuasive or motivational design strategies. Design for behavior change posits that by identifying the appropriate motivational affordance of the user and increasing usability, a technology will be much more likely to be successful in addressing the intended behavior. This design approach has significant relevance to older adults in that it supports adaptive and responsive interactions by providing in-time feedback, coaching, and task support. In order to implement this

design approach researchers must identify and understand what factors are associated with older adults' acceptance and adoption of health technologies.

Thus, my proposed dissertation research sought to establish the evidence base for the design of mobile health technologies that target physical activity behaviors among older adults. This research specifically looked at the design of mobile health and fitness apps to discern their relevance and effectiveness for a sample of older adults. To do so, I designed two research studies. The first study sought to understand the constructs and motivating factors associated with older adults' physical activity behaviors and identify motivational design strategies that support these constructs and motivators. The goal of the second study was to discern the effectiveness of mobile fitness apps that leverage these motivational design strategies. This second study examined the effect of two existing mobile fitness apps (one app framed by social support and one framed by goal support) on older adults' physical activity levels and attitudes towards mobile health technologies.

Findings from this research indicate that social support from family and friends was both reported as a key motivator for older adults initiating and maintaining recommended levels of physical activity, and showed trends of encouraging higher physical activity levels when compared to goal support as a strategy. Despite positive trends in performance metrics, social support as a currently implemented design strategy was not preferred among participants for sustained use of a health technology. Older adults commented that one-on-one connections and a more holistic approach to health and wellness are features that would increase their overall acceptance and adoption of health and fitness apps.

This research contributes to the field of design and human-computer interaction (HCI) through a mixed-method approach to examining effective features of health

technologies, distinguishing this research from previous research efforts that have leveraged either a qualitative or quantitative research approach. Additionally, findings from this work inform evidence-based design guidelines for the design of future technologies that are inclusive of older adult needs.

## **CHAPTER 1. INTRODUCTION**

Maintenance of health and physical well-being contribute to the overall quality of life for individuals as they age. Despite the known benefits of physical activity, many older adults do not meet the recommended levels of exercise or physical activity, preventing the health benefits that are often seen from living an active lifestyle. There has been an emergence of mobile health technologies in the form of mobile health and fitness apps and technologies which address physical activity and other health-related behaviors through monitoring, tracking, and displaying real-time information based on a user's actions. Although use of these apps has the potential to positively affect physical activity in older adults, many of these apps are currently under-utilized, often due to lack of motivational affordance and poor consideration for system usability and accessibility. Employing behavior change techniques and strategies to encourage users to perform certain pre-determined behaviors has been proven to be an effective approach to developing successful apps (Chen et al., 2014; Middelweerd et al., 2014; Voth et al., 2016), though this approach is not common practice. Motivation is a key underlying structure of behavior change and an important component to tailoring technologies to their intended target population. Thus, successful technologies should be informed by an in-depth understanding of the barriers, facilitators, and motivating factors to a target health behavior.

Common approaches to design for behavior change include the concept of persuasive design, or the design of computing systems and technologies as interventions to change behaviors and attitudes through persuasion and social influence. This design

approach employs various design techniques aimed at achieving behavior change by supporting users through four psychological constructs of primary task support, dialogue support, system credibility support, and social support. Although this approach of persuasive design has evidence-based short-term potential to encourage positive practices in the general health and wellness domain, it is unclear the longitudinal effect of this and similar approaches to design for behavior change within the older adult population. Specifically, empirical proof of the relevance and effectiveness of behavior change techniques to the older adult population has yet to be established.

Thus, the overarching purpose of this dissertation project was to discern the most effective motivational design strategies as seen in mobile health and fitness apps that encourage physical activity among older adults. I proposed to investigate how the underlying constructs of motivation and persuasion when applied to the interface design of mobile health and fitness apps can increase physical activity within the older adult population. While research suggests that there is a correlation between the use of mobile health and fitness apps and increased physical activity, very few studies have examined this effect among older adults over a long duration of time to discern whether the target behavior has been changed. Additionally, many studies in this area have failed to address that both usability and functionality play vital roles in the sustained use of any interface-based technology, and that integrating universal design principles would be a feasible approach to increasing the usage of many mobile health and fitness apps. Understanding these psychological constructs and how they are seen within design techniques applied to

mobile health and fitness apps informs evidence-based guidelines for future mobile health technologies.

### **Research Approach**

To address this research area, a three-phase research approach was used to define and examine the effectiveness of motivational design strategies, when applied to mobile health and fitness apps, to increase physical activity among older adults. First, an analysis of semi-structured interview data regarding determinants of older adults' physical activity behaviors was conducted. This analysis resulted in the identification of motivating factors associated with older adults engaging in physical activity, and the implications for motivational design strategies and behavior change techniques for mobile health apps were identified. There were six motivational design strategies defined as a result of this analysis: social influence, coaching, goal support, awareness, positive affect, and adaptation. Second, I evaluated existing mobile fitness apps for their implementation of these motivational design strategies and behavior change techniques. From this evaluation, I identified three mobile fitness apps to deploy and test for effectiveness of increasing physical activity levels and mobile fitness app engagement. Each of these apps was deployed in a semi-longitudinal study with older adults in the Atlanta area for a period of 10 weeks. I examined two specific motivational design strategies in this study for their effect on physical activity and mobile fitness app engagement: goal support and social influence. This study focused on understanding the aspects and features of mobile health and fitness apps that are effective for older adults, and motivational design strategies that are relevant to various contexts of use.

## **Objectives and Outcomes**

The specific objectives of this dissertation were to (1) identify and understand key motivators and facilitators to older adults initiating and maintaining physical activity; (2) assess existing taxonomies and frameworks for their inclusion of identified key motivators and knowledge of age-related limitations; (3) discern effectiveness of relevant behavior change techniques specifically for older adults; and (4) develop design guidelines and proof of concept for a mobile fitness application leveraging effective behavior change techniques and principles of universal design.

Immediate outcomes of this research will be a set of design guidelines that inform future mobile health technologies that foster health behavior change among older adults. These guidelines will be used to develop a concept for a mobile fitness app that addresses the user needs and criteria outlined throughout this dissertation.

## **Contributions**

Results of this study inform guidelines for the design of mobile health technologies for successful engagement among the aging population, as well as evidence-based design guidelines for health and fitness apps effective in motivating physical activity behavior change among older adults. As recent studies have explored the potential of mobile health technologies to increase physical activity and exercise among various user groups, with new focus on older adults, it is of value to design and HCI research communities to explore this area by applying persuasive and universal design principles to evidence-based constructs from behavior change theory. Additionally, this dissertation research contributes



to design research methodology through the use of both qualitative and quantitative methods in discerning the effectiveness of design strategies.

### **Organization of the Dissertation**

Chapter 1 presents an introduction to overall dissertation including the statement of the problem, purpose of the dissertation, objectives, outcomes and intended contributions. Chapter 2 of this dissertation presents an exhaustive literature review on mobile health and fitness apps to address physical activity deficits among older adults as a background to the research. This review also goes in depth in understanding the factors that contribute to technology acceptance and usage, and proposes considerations specific to older adults, suggesting the need for qualitative investigation in this area. Chapter 3 provides an overview of the research to be conducted including research questions, hypotheses, research design and rationale for all research activities presented. Chapter 4 presents the first research study as an analysis of qualitative interview data exploring the barriers, motivators, and facilitators to older adults initiating and maintaining a physical activity regimen. Here I introduce six motivational strategies as key findings and implications for the design of mobile health technologies. Chapter 5 discusses in-depth the motivational strategies introduced in Chapter 4, discusses proposed behavior change techniques that align to each strategy, and reviews existing frameworks and taxonomies for the inclusion of these strategies. I also present an evaluation of existing mobile fitness apps based on these motivational strategies and proposed behavior change techniques. Chapter 6 presents the second research study, which evaluated the effectiveness of three existing mobile fitness apps that each align to a different motivational strategy. This semi-longitudinal

study investigated the ability of these three conditions to increase the physical activity levels of older adults from a baseline measurement. The conclusion of this chapter discusses the implications of these findings for the design of future health and fitness technologies. Chapter 7 presents the second part of Study 2 which consists of group co-design sessions following the semi-longitudinal study. From these co-design sessions, I identify ideal features and components of health and fitness technologies as expressed by participants of Study 2. Chapter 8 discusses insights stemming from the semi-longitudinal evaluation (Study 2) and contributions to theory. Chapter 9 discusses the design of motivational and inclusive mobile health technologies for older adults based on the major findings of the two studies of this dissertation, and concludes with lessons learned related to both method and design application.

## **CHAPTER 2. BACKGROUND & LITERATURE REVIEW**

The ability to age successfully is determined by an individual's independent maintenance of physical and mental health; support of social interactions; and delaying the onset of disability for as long as possible (Fries, 2002; Rowe & Kahn, 1997). Oftentimes challenges faced in the domains of independent self-care and maintenance could be overcome by a healthy diet and routine exercise. Routine physical activity and exercise have a positive impact on older adults' physical and cognitive health (e.g., lower blood pressure, improved heart conditions, increased mental stimulation), in addition to presenting opportunities for social interaction (Bherer et al., 2013). Additionally, improved physical and cognitive functioning could potentially delay the onset of disability and chronic illness experienced in later adulthood. However, many older adults fail to adhere to recommended levels of moderate to vigorous physical activity or routine exercise regimens necessary to maintain good health as outlined by healthcare professionals (Schiller et al., 2012).

### **Physical Activity Deficits Among Older Adults**

Levels of physical activity and exercise see a significant decrease as the age of individuals increases (Nelson et al., 2007). The National Health Interview Study reports that only 15.3% of older adults met the federal physical activity guidelines of 150 minutes of moderate to intense physical activity (aerobic and muscle-training activities) per week in 2016 (Clarke et al., 2017). This number drops to 8.7% among adults 75 and older (Clarke et al., 2017). Older adults report many barriers and challenges to initiating and sustaining

routine physical activity and exercise including physical limitations, lack of access to facilities, not knowing how to initiate an exercise regimen, or lack of motivation and social support (King & King, 2010; Kravitz, 2011; McAuley, 1993; McAuley et al., 2007). Alternative, theoretically-based, behavioral approaches to exercise such as in-home exercise programs and one-on-one coaching have been reported as more successfully engaging older adults in these activities (King et al., 1991; Wilcox et al., 2008). Even so, many individuals find it hard to stick with these programs, whether due to time limitations or what is known as typical drop-out- 50% of persons that begin an exercise program will drop out within the first six months (Wilson & Brookfield, 2009).

With such a low percentage of the older adult population meeting recommended fitness levels despite known relevant health-related benefits, it is necessary to identify effective approaches to motivating older adults to become more physically active. For the motivational approach to be effective, researchers must know what prevents the behavior, and why certain facilitators are perceived as successful. Understanding the relevant constructs to promoting physical activity could lead to effective development criteria for health technologies. Thus, knowledge of the barriers and motivators to physical activity among older adults is vital to the development of successful technologies addressing this area.

### **Understanding Constructs Surrounding Physical Activity Behaviors**

Engagement in physical activity is determined by various social and environmental factors including access to facilities and social influence from friends and family, as well as psychological constructs such as self-efficacy (the confidence an individual has in their

capacity to perform an activity) and self-regulation skills as expressed by one's ability to set relevant and obtainable goals regarding physical activity (King & King, 2010; Park et al., 2014). Research efforts studying the effectiveness of behavioral intervention programs have differed regarding the most effective motivators for older adults, some stating that one-on-one coaching has the most promise to increase physical activity levels, whereas others suggest that group environments and social support are the most effective. Most research, however, supports that factors which ultimately lead to behavior change are often tied to psychological, biological, social, and cultural factors (Kravitz, 2011). Behavior and goal-setting theories have proposed that goal-setting and task performance are directly related, with both intrinsic and extrinsic motivation being key components to meeting one's personal goals.

Previous studies have examined the importance of physical environment on physical activity behaviors, identifying access to facilities and the structure of walkways and neighborhoods as being a key determinant of physical activity behaviors among community-dwelling older adults (Van Cauwenberg et al., 2012). A qualitative interview study assessing the environmental factors that lead to older adults walking highlighted environmental facilitators such as accessible trails as well as sidewalk quality as playing important roles in the frequency with which older adults chose to walk for leisure or exercise versus transportation (Van Cauwenberg et al., 2012). Additionally, studies have examined the correlation of the social influences on older adults' physical activity behaviors, indicating that older adults are more likely to be physically active if they are accompanied by a peer (Wendel-Vos et al., 2007). Several randomized control trials such

as Cheung et al. (2006) and Costanzo and Walker (2008) found that self-efficacy also had a positive impact on the physical activity levels of older adults.

Although previous studies have quantified the effects of certain factors on the physical activity behaviors among older adults, there is still an opportunity to gain in-depth insight of the constructs that motivate older adults to initiate and maintain physical activity through qualitative inquiry. To frame the factors successful in motivating physical activity performance, it is also necessary to better understand how physical activity is considered among this population, specifically the types of activities that are of interest in older adulthood. Additionally, while there is knowledge of the barriers which prevent physical activity performance among older adults (Bjornsdottir et al., 2012; Moschny et al., 2011), it is instrumental to identify the ways in which this population establishes facilitators to overcome these barriers. Understanding these constructs (barriers, facilitators, and motivators) may inform successful interventions for physical activity promotion such as the use of health and activity tracking technologies which have become a prevalent way of encouraging physical activity.

Studies examining the effectiveness of mobile health technologies have found that these systems may increase confidence in correctly executing physical exercises and activities among users with impairments or dexterity decline (Doyle et al., 2011), in addition to increasing physical activity outside of the home for older adults (Malliot et al., 2012). In a study by Maddison et al. (2014), an evaluation of the Heart Exercise and Remote Technologies (HEART) mobile phone trial found a significant impact on self-efficacy and exercise adherence among adults. As such, mobile health and fitness apps as

an intervention approach have great potential to address the issues of insufficient physical activity among older adults, and acceptance of these technologies could lead to an increase in the overall quality of life of individuals over 65.

### **Mobile Health Technology as an Approach to Physical Activity Promotion**

There has been a recent emergence in the use of mobile health technologies to encourage physical activity and exercise (Aitken & Ganttlett, 2013; Litman et al., 2015). Mobile health technologies (wearable fitness trackers or mobile health and fitness apps) communicate a user's health information and behavior through visual displays providing text, images, videos, and/or simulated activities to deliver encouragement for physical activity or to demonstrate various forms of exercise. These technologies are often used to manage a specific chronic illness such as diabetes or blood pressure levels (Borghese et al., 2013; Chang et al., 2012; Saposnik et al., 2010), or as a consumer approach to tracking activity levels and nutrition. These technologies often leverage techniques such as coaching, activity instructions, or challenges to immerse users in seemingly engaging activities while getting users to be physically active. Mobile health and fitness apps deployed through smartphones are a potential solution to the barriers to physical activity among older adults, with potential to enhance the frequency and method of how users perform exercise and therapeutic activities (Cornman et al., 2005; Pape et al., 2002), in addition to introducing new methods of physical activity to otherwise sedentary individuals (Lieberman et al., 2011; Malliot et al., 2012; Nawaz et al., 2014). With advances in location recognition and tracking, many smartphones are now able to provide real-time feedback

and prompting. As such, these technologies present as a viable approach to engaging and sustaining older adults in recommended levels of physical activity and exercise.

When compared to community-based behavior change programs, mobile health technologies such as health and fitness apps have the benefit of providing users with consistent direct access to fitness encouragement largely due to: sensor tracking that allows for real-time activity sensing; responsive interfaces that provide an immersive and interactive experience; customized feedback; and portability of the mobile phone allowing it to be carried around with the user on a consistent basis (Lieberman et al., 2011; Malliot et al., 2012; Nawaz et al., 2014). Evidence suggests that technologies designed to promote the initiation and maintenance of physical activity behaviors may be a feasible intervention to physical activity deficits (Tate et al., 2015).

Developing technologies that successfully encourage adherence to routine exercise and positive attitudes associated with physical activity can be a challenge for researchers and designers. Although the number of mobile health technologies has seen a recent increase with proven benefit to the support of daily functioning and performance of maintenance activities (Gay & Leijdekkers, 2015; Mohr et al., 2013), users still report deficits and challenges in the area of physical activity and health tracking (Shih et al., 2015). For older adults, mobile health technologies have the potential to not only improve physical activity levels, but to also increase social interaction, brain functioning, and support performance of activities deemed instrumental to their daily living (medication management and consumption, diet and hydration) (Dahlke & Ory, 2016). Thus, understanding the use trajectory of health technologies and the factors associated with



abandonment or continued use will support better designed technologies that see more consistent engagement with end users.

### **Adoption of Mobile Health and Fitness Applications**

Despite the potential benefits of the use of mobile health and fitness apps, many often see lower usage rates for various reasons, including system complexity, poor fit of user needs, and a failure to adequately motivate the user (Meyer et al., 2016). Additionally, these systems are often not designed with older users in mind (Helbostad et al., 2017). Low usage resultantly prevents potential benefits from being seen leaving question to the actual long-term change in behavior and attitudes seen by the intended users of the system.

The Pew Research Center reports that nearly 77% of the overall U.S. population currently own a smartphone, with 42% of adults aged 65 and older owning a personal smartphone (Pew Research Center, 2017). Of this population of smartphone owners, 31% use their devices to download mobile health and fitness apps to search for health information or track their health status (Pew Research Center, 2017) with nearly 165,000 mobile health apps existing across the iPhone, Google Play, and Android platform app stores. Despite this prevalence of health and fitness apps, there are still low reports of use of these apps due to many barriers related to acceptance and adoption. Studies suggest that many mobile health apps see low adoption rates, inconsistent use, and a lack of user engagement for long periods of time (Bickmore et al., 2010; Bort-Roig et al., 2014; Burke et al., 2015; Klasnja et al., 2009). Previous research studies of mobile health and fitness app use suggest that many of these systems are often abandoned anywhere between three to six months after their download. In a survey examining the usage trajectory of mobile

health and fitness apps, researchers found that 35% of existing apps that are downloaded to personal smartphones or tablets are abandoned within the first three months of their initial download (Murnane et al., 2015). Such low adoption and utilization rates prevent the actualization of health benefits associated with continued use.

Various factors can be attributed to this low usage, including burdensome workflows, ineffective system engagement strategies, and low system usability associated with a lack of consideration for functional limitations and age-related challenges. The Technology Acceptance Model (TAM) indicates a direct contribution of system ease-of-use and system usefulness to system use by the end user (Davis, 1986; Davis, 1989). Ease-of-use, or the usability of the system, is an aspect included in the concept of mobile user experience, and is important to consider as having a direct relationship to system adoption and sustained engagement (Zapata et al., 2015). For purposes of this dissertation research, I define the concept of usability as the measurement of a product's expected functionality and accessibility, which for older adults who may experience physical and sensory impairments may include a system's adherence to universal and inclusive design principles. A second major factor of acceptance of a system is the perceived usefulness, or relevance, the system has for the user. In this way, the relevance of app content plays an important role in technology acceptance, and is potentially influenced by the motivational affordance of the technology itself. Examining each of these factors is of great value to understanding why users sustain use of, or abandon mobile health and fitness apps.

## **Determinants of Acceptance and Adoption**

### Universal and Inclusive Design of Mobile Health Apps

Although various apps exist that promote health behaviors and management of chronic illnesses and diseases that are prevalent among older adults, many of these apps are not considered usable by older users (Dahlke & Ory, 2016). Various studies report challenges experienced during interactions with mobile health technologies, including usability barriers expressed by older adults (Dahlke & Ory, 2016; Isakovic et al., 2016; Watkins et al., 2014; Whitlock & McLaughlin, 2012). Existing mobile apps are often perceived to be too complex (Watkins et al., 2014; Whitlock & McLaughlin, 2012), move at a pace not conducive to users who require a longer learning time (Isakovic et al., 2016), or were not legible to the decreased visual acuity of many older users (Whitlock & McLaughlin, 2012). In a usability assessment of existing glucose tracking apps, Whitlock & McLaughlin (2012) found that apps presented poor visual contrast and small text and button size, having negative implications for older adult use. Similarly, in a heuristic evaluation of healthy eating apps for older adults, Watkins et al (2014) found five nutrition apps to feature, complex navigation and workflow, poor contrast, unfamiliar iconography, and insufficient instructions.

As a result of varying usability challenges, many older adults report abandoning and never adopting potentially useful mobile health apps. Use of mobile health apps is seen to decrease with age among adults 60 and older, with only 10% of adults aged 65 and older choosing to adopt the use of these apps (Dahlke & Ory, 2016). Despite such low use, 42% of older adults surveyed by AARP reported an interest in utilizing mobile health and fitness

apps due to their perceived benefits (Barrett, 2011). Studies evaluating older adults' experiences with these apps conclude that lower usage rates and lessened likelihood of adoption is often associated with challenges perceived in using these apps including the accessibility of app interfaces with regards to screen contrast, text legibility, alternate cues and notifications and an understanding of language and icons (Barrett, 2011; Dahlke & Ory, 2016; Whitlock & McLaughlin, 2012). Usability is often not a major consideration in the development of mobile health app interfaces, thus suggesting a need for a design approach more inclusive of older users.

#### Motivational Affordance as Technology Usefulness

In addition to the examination of app usability, motivational affordance may contribute to the acceptance of mobile health and fitness apps. Many mobile health and fitness apps lack the use of behavior change theories to promote physical activity (Middelweerd et al., 2014). Recent reviews of existing health and fitness apps have concluded that although there is an ever-increasing emergence of these apps to support physical activity, there is an overarching lack of theoretical constructs present in their design (Al Ayubi et al., 2014; Cowan et al., 2012; Direito et al., 2014; Hekler et al., 2011; Michie et al., 2008). Many studies that have assessed the effectiveness of mobile health and fitness apps have recommended the integration of successful evidence-based behavior change strategies to improve exercise and physical activity adherence. Since there is empirical evidence to support the effectiveness of behavior interventions to physical activity and diet behaviors, it makes sense to assume that integrating these same principles into the design of mobile health and fitness apps would elicit positive results. However,

Riley et al. (2011) suggests that current health behavior theories do not account for the interplay between user experience and the dynamic and adaptable nature of mobile apps. More needs to be known about the motivating factors of the intended users and how this interacts with the content of mobile health apps.

As such, it is important to understand the key motivators to older adults engaging in routine physical activity and exercise, and how mobile health and fitness apps can be designed to promote healthy behaviors and sustained use. To design technologies that effectively address the needs of older adults, there is a need for an in-depth understanding of what motivates activity or exercise.

### **Design for Behavior Change as an Approach to System Adoption**

#### Defining Design for Behavior Change

Design for behavior change is a design approach in which products and technologies are designed to shape human behavior and attitudes. Theories and models that make up this design approach most commonly fall under design for healthy behavior, or persuasive design. Design for healthy behavior (Ludden & Hekkert, 2014) leverages the Transtheoretical Model of behavior change which frames that designers should consider the various stages of behavior change when designing technologies that target health-related behaviors (Prochaska & Velicer, 1997). Persuasive design as a behavior change approach contends that technologies are designed with certain principles or design strategies which are based on motivational determinants of a behavior (Fogg, 2002). In addition to design strategies, these models are also comprised of behavior change

techniques which are defined as theory-based method used in technology or product interventions for changing behavior by addressing a person's attitude or self-efficacy (Bartholomew et al., 2011).

The characteristics of persuasive design or persuasive technologies as outlined by Fogg (2002) position them to be an effective solution to the issue of low technology use, primarily due to these technologies being tailored to a user's particular needs and abilities. The persuasive design approach creates technologies that are intended to be user-sensitive, user-adaptive, and responsive. Persuasion in these technologies is often seen through virtual coaching, individual goal-setting, or the implementation of motivational frames. To implore these methods, persuasive technologies are designed with specific design techniques that address a particular domain of task support.

#### Previous Research Applications

Previous research efforts in the area of design for behavior change have focused on the development of persuasive technologies for younger adults and adolescents in areas of physical activity (Chittaro & Sioni, 2012; Consolvo et al., 2008; Dominic et al., 2013), hydration (Chiu et al., 2009), and medication consumption (Sterns & Mayhorn, 2006). Additionally, there is a significant body of work published in the area of developing and testing persuasive technologies targeting physical activity promotion for the general population. Tested prototypes in this area include multi-components systems to track an individual's steps while prompting continued activity through glanceable and dynamic displays (Albaina et al., 2009; Consolvo et al., 2006; Consolvo et al., 2008). Studies evaluating the effectiveness of these technologies concluded that technologies that feature

glanceable displays helped users to maintain consistent behaviors (Ananthanarayan, 2012). Consolvo et al. (2008) found that users had a positive interaction with Ubifit, a garden simulation on a mobile phone interface that encouraged physical activity through positive reinforcement and allowing the user to watch a virtual garden grow. Findings from this study also support the notion that successful persuasive technologies to promote physical activity must also accommodate the changing needs of the user. In the evaluation of a mobile-phone based fitness journal called 'Houston', researchers discerned that another key strategy to designing successful persuasive technologies is the aid of reasonable goal-setting (Consolvo et al., 2006).

Flowie (Albaina et al., 2009) was a technology designed specifically for older adults to increase walking levels. This technology utilized a small-touch screen display in conjunction with a pedometer to track a user's steps and communicate their progress by the growing of a flower. This technology relied heavily on the intrinsic motivation of the user, implementing activity promotion through self-monitoring, conditioning, and classic learning theory. Results indicated increased amounts of steps, a positive reaction to the display, and a high intent to use among participants. More recent studies such as those conducted by Chen et al., (2014); Direito et al. (2014); King et al. (2013); and Rodriguez et al. (2012) have also shown that various approaches to persuasive technologies for physical activity promotion have had initial success, and that social engagement and system feedback are among the key contributing factors to individual temporary adherence to routine physical activity and exercise.

Design for behavior change approaches such as persuasive design may have potential for influencing behaviors that can lead to healthier lifestyles for older adults specifically (de Kort et al., 2005). However, due to age-related limitations (e.g., lower visual acuity, technology experience, cognitive changes), integrating effective persuasive design techniques relevant to older adults can be a challenge (Hawthorn, 2000; Pak & McLaughlin, 2011), and determining the long-term success of these techniques has not been explored in-depth.

### Effectiveness Among Older Adults

In reviewing research related to technologies and apps that utilized persuasive design or design for behavior change, few studies were identified to have empirically tested the effectiveness of motivational design strategies and behavior change techniques specifically for the older adult population. Several studies published assessed the usability of the system design, identifying strategies and heuristics recommended for designing motivating systems for older adults (Rodriguez et al., 2012; Vankipuram et al., 2012; Watkins et al., 2014). Both the ReadySteady app designed by Vankipuram et al (2012) as well as the Calm Application for Motivating elders to Move by Interacting with their Age group (CAMMInA) utilized motivational messages and trended history feedback to encourage older adults to increase the frequency, intensity, and duration of physical activity. Researchers based the motivational strategies used in this app on the Wellness Motivation Theory which posits that motivation is complex and thus focuses on how people set goals, assess opportunities for change and then initiate that change (Fleury, 1996). Although these efforts evaluated the use of these strategies by the user's perception of



them, effectiveness of the system and use of motivational messages was not established. In a study conducted by Paul et al (2017), researchers found that by utilizing self-monitoring, feedback, and social support, a physical activity app was able to increase older adults' step count by 14% over the course of six weeks, however this study was conducted with a relatively small sample size ( $N=8$ ). Although these studies have leveraged theory-based behavior change techniques, there is still a need for a more empirical testing of the effectiveness of these techniques specifically among older adults.

### **Research Opportunities**

Despite the known benefits of mobile health technologies, they have yet to become widely adopted and consistently used. Design for behavior change as seen by approaches such as persuasive design may be a viable approach to successfully engaging end users in consistent interaction with mobile health technologies. Applying evidence-based behavior change techniques to mobile health technologies has the potential to increase the overall use of these technologies by not only encouraging users to change a target behavior, but encouraging long-term interaction with the technology itself.

Although the concept of persuasive design and other implementations of design for behavior change have been applied to various domains, few resulting apps have leveraged behavior change theory or evidence-based guidelines into system design (Middelweerd et al., 2014). Most studies in this area leverage gamification as a motivational design strategy (Albaina et al., 2009; Consolvo et al., 2006; Consolvo et al., 2008), and while there is some value to this approach in certain contexts, persuasion as a design strategy may come with some limits stemming from functional ability and sources of motivation. Relatively few

studies evaluating persuasive design techniques have specifically looked at the effectiveness of these technologies for older adults. Additionally, although many research efforts in this area have acknowledged low usage and issues of sustainability with mobile health and fitness apps, there is a lack of empirical studies that have addressed usability as a factor of motivation and behavior change, in addition to its relevance as an approach to increase the sustained use of mobile health and fitness apps. In addition to studying the determinants of mobile health and fitness app use, there is opportunity to establish evidence to support the implementation of behavior change techniques that have a positive impact on the use of mobile health technologies over extended durations of time.

Much of the previous research conducted in the area of technologies for health-related behavior change have leveraged general taxonomies of behavior change techniques, with an emphasis on younger and middle-aged adults. Very few empirical studies examine the ability of these technologies to use a user-centric evidence-based approach to identifying relevant mobile fitness apps to evaluate. Additionally, few empirical studies have shown a significant impact on the behaviors and attitudes of adults over the age of 65. This lack of evidence suggests that there is a need for a more in-depth investigation of the effectiveness of persuasive design techniques and their value to older adults.

## **CHAPTER 3. OVERVIEW OF THE RESEARCH**

### **Focus and Scope of the Research**

The main focus of this dissertation was to identify and evaluate the ability of relevant motivational design strategies to encourage older adults to initiate and sustain routine physical activity and exercise. As a novel approach to this investigation, I assessed existing mobile fitness apps based on behavior change theories that have been shown to be effective, along with psychological constructs expressed as being direct determinants of physical activity. Additionally, system usability was examined as a factor of technology adoption and acceptance following a semi-longitudinal period of app use.

For this dissertation work I focused solely on mobile fitness apps that encourage physical fitness or exercise through acknowledging a user's behaviors and providing feedback through some form of motivational strategy. This dissertation did not focus on apps that track diet or nutrition in any way, or those that are purely video-based.

### **Research Questions and Hypotheses**

The research described in this dissertation examined the ability of motivational design strategies and associated behavior change techniques to effectively increase and sustain the levels of physical activity of older adults. The overarching question at the core of this research was:

*“How can persuasive mobile fitness apps best support long-term physical activity behaviors such that older adults successfully initiate and sustain routine levels of physical activity and exercise?”*

I propose that framing mobile health and fitness apps with relevant motivational design strategies will positively influence the perceived usefulness and effectiveness of apps as a health behavior change intervention. Previous research in the area of mobile health technologies for behavior change as well as behavior change theory suggest that utilizing behavior change techniques to inform the design of mobile health and fitness apps will ultimately affect the long-term use and associated health-related behaviors of target end users. Identifying key factors of a target behavior as expressed by the intended user will inform motivational design strategies that are more effective in changing a behavior. Thus, I hypothesize that older adults' interactions with motivationally designed apps will result in an increased level of sustained physical activity, as measured by minutes of daily activity, compared to their baseline performance.

To fully achieve this research goal, the overarching question was divided into the following research questions and hypotheses:

*1. What are the key barriers, facilitators, and motivating factors that influence older adults' beginning and maintaining recommended level of physical activity?*

**H1:** Social influence is a key motivating factor to addressing the physical activity behavior change needs of older adults as identified through user interviews.

*2. Which factors inform new, age-relevant motivational design strategies and behavior change techniques for mobile health and fitness apps?*

**H2:** Motivating factors of physical activity as expressed by older adults that will result in additional, age-relevant behavior change techniques as compared to existing taxonomies and frameworks.

**3.** *When applied to mobile fitness apps, how effective are social influence and goal support as motivational strategies in increasing levels of physical activity from baseline performance such that behaviors continue after initial use of the technology?*

**3.1.** *Which behavior change techniques are considered motivational in sustaining use of a mobile fitness app among older adults over a sustained period of time?*

**H3:** Mobile health and fitness apps that foster social influence will demonstrate the largest increase in consistent physical activity compared to those that foster goal support as measured by increased minutes of daily activity over baseline performance.

**H3.1** Behavior change techniques that support social influence and goal support will be considered most motivational.

**4.** *What factors contribute to the use and non-use of a mobile fitness app among older adults?*

**4.1.** *Is there an effect between the usability of the app and the sustained use of the app?*

**H4:** Both factors of perceived usefulness (effectiveness of the app meeting user needs) and perceived ease-of-use (how easy the app is to learn to use) will contribute to the use or non-use of the app.

**H4.1** Mobile health and fitness apps that leverage inclusive and universal design principles will be more usable and thus will see more sustained use.

5. *What are the most desired features and elements of health and fitness apps intended for health-related behavior change?*

## Research Methods

To investigate the research questions presented above, I conducted two studies to understand the key motivators associated with physical activity from the perspective of older adults, and to evaluate the ways design strategies can embody these motivations and effectively encourage behavior (Table 1).

**Table 1. Methods to address research questions**

	Method	Outcome Variables
Q1/H1	analysis of semi-structured interview data (Study 1)	barriers, facilitators, motivators to physical activity
	frequency analysis of qualitative themes (Study 1)	
Q2/H2	analysis of literature	
	map identified motivators to behavior change techniques	
Q3/H3/H3.1 Q4/H4/H4.1	semi-longitudinal comparative study (Study 2)	levels of physical activity
		attitudes/perceptions regarding physical activity
		usability, perceived usefulness, and desirability of app
Q5	group interviews and co-design session (Study 2)	ratings of behavior change techniques, brainstormed features

Study 1 consisted of an analysis of qualitative interviews on physical activity behaviors, resulting in a better understanding of the constructs that are associated with

physical activity and the design implications and strategies that stem from these constructs. Study 2 was a semi-longitudinal evaluation of existing mobile health and fitness apps to discern the effectiveness of certain motivational design strategies defined by the findings from Study 1. This dissertation effort used both qualitative and quantitative data collection and analysis methods at various stages of the research to combine the in-depth, detailed analysis of the qualitative interviews and focus groups, with the larger-scale generalizability of survey and questionnaire data, to provide a rich picture of the effect of motivational design strategies on physical activity metrics as well as the perceptions of these strategies.

The goal of the interview analysis was to assess the prevalent psychological constructs that older adults considered relevant to initiating and maintaining recommended levels of physical activity, addressing RQ1 and RQ2. Semi-structured interviews of 16 older adults were transcribed, coded, and analyzed to extract the common barriers, facilitators, motivators, and goal-setting techniques associated with older adults being physically active. There were two primary aims of this analysis: First, to identify and understand the common psychological constructs associated with physical activity; and second, to identify evidence-based design strategies of mobile health technologies incorporating these constructs.

The goal of the second study was to evaluate existing mobile fitness apps that incorporated these evidence-based design strategies for their effectiveness in increasing physical activity and encouraging sustained use of the app itself. Findings from this study addressed RQ3 and RQ4. This study was designed as a semi-longitudinal assessment of

app use over the course of 10 weeks. Participants were assigned to using one of three different mobile health and fitness apps that embodied a different motivational strategy. Participants completed surveys and questionnaires about their experience, changes in activity levels, and attitudes towards mobile fitness apps.

As a part of the final follow-up assessments, participants engaged in group co-design sessions to ideate ideal design characteristics and features for future health and fitness apps. Findings from these sessions were used to address RQ5 and develop evidence-based design guidelines for future motivationally framed health and fitness technologies.

### **Rationale for Research Approach**

The research described in this thesis is centered on the design and evaluation of motivationally framed mobile health and fitness apps as intervention approaches to deficits in physical activity among older adults. Although there have been similar research investigations in this area, this dissertation relied heavily on theoretical constructs and a methodological approach derived from public health and behavior change literature, as well as rich, in-depth qualitative data-driven design strategies.

Fogg's theory of persuasiveness outlines the rationale for examining the psychological constructs related to older adults engaging in physical activity. His work posits that it is important to initially understand the barriers to users engaging in an activity, here older adults engaging in physical activity, as well as the intrinsic and extrinsic sources that show promise in being effective in changing this behavior. Additionally, the framework for designing and evaluating complex health-related interventions as established by the UK Medical Research Council (Medical Research Council, 2010;



Campbell et al., 2000; Campbell et al., 2007) suggests that prior to modeling a proposed intervention it is essential to establish a theoretical basis for that intervention.

Leveraging behavior change theories which address health-related behaviors, two theories are positioned as being particularly relevant to the topic of encouraging physical activity for older adults; the Transtheoretical Model of Health Behavior Change (Prochaska & Velicer, 1997), and the Social Cognitive Theory (Bandura, 2001). These theories detail the stages of change and psychosocial factors that attribute to attitudes and behaviors changing as a result of an intervention, providing a theoretical foundation for developing technologies that encourage such a change in attitudes and behaviors. Similarly, models of persuasion in persuasive technology literature identify psychological principles that serve as the basis for a variety of persuasion and motivation techniques implemented in persuasive technologies. These models, Psychology of Persuasion (Cialdini, 2009) and the Persuasive Systems Development model (Oinas-Kukkonen & Harjumaa, 2009) also informed the methodological approach of this research.

## **CHAPTER 4. UNDERSTANDING PHYSICAL ACTIVITY BEHAVIORS OF OLDER ADULTS (STUDY 1)**

### **Overview**

There is a need to understand the key barriers and facilitators as constructs of physical activity among older adults in-depth through qualitative methods. In addition, there is value in examining the difference among these constructs as perceived by those who are frequently physically active and may meet the recommended physical activity guidelines those that are considered infrequently active. This approach, identifies barriers and facilitators related to physical activity among older adults, in addition to factors related to why and how certain barriers or facilitators present themselves, and better identify criteria for potential interventions.

Although previous studies have quantified the effect of certain factors on the physical activity levels among older adults, there is still opportunity to gain in-depth insight of the constructs that motivate older adults to initiate as well as maintain physical activity through qualitative inquiry. To frame the factors successful in motivating physical activity performance, it is also necessary to understand how physical activity is considered among older adults, specifically the types of activities that are of interest in older adulthood. Additionally, there is a need to understand the barriers to current physical activity performance, and in what ways older adults establish facilitators to overcome these barriers. Understanding these constructs may inform successful interventions for physical

activity promotion such as the use of health and activity tracking technologies which have become a prevalent way of encouraging physical activity.

To address the need for a better understanding of the psychological constructs associated with physical activity behaviors among older adults, this study and analysis aimed to uncover relevant variables to older adults initiating and maintaining physical activity (defined as any bodily movement that is not a structured or intentional fitness activity that results in energy expenditure (Caspersen et al., 1985)) and exercise (defined as planned, intentional, or structured activities that are repetitive and which have a final or intermediate objective to improve or maintain physical fitness (Caspersen et al., 1985)). To obtain detailed information regarding these behaviors, semi-structured interviews were conducted and analyzed by a thorough qualitative analysis, yielding several themes relevant to designing effective mobile health technologies targeting physical activity promotion. This analysis addresses RQ1 in identifying key motivating factors for physical activity behaviors.

## **Method**

### **Participants**

Sixteen older adults (eight male) aged 65-84 years ( $M = 74$ ;  $SD = 4.6$ ) were recruited from the Human Factors and Aging Laboratory Participant Registry, which is a database of older adults willing to participate in research studies in the area local to Atlanta, GA, USA. To be included in this study, individuals had to meet the age criteria and were screened for their current engagement in physical activity and exercise. Based on this

screening, eight participants were categorized as infrequent exercisers (exercised 2 days a week or less), and eight participants were categorized as frequent exercisers (exercised 4 days a week or more).

### Protocol and Measures

The protocol consisted of two parts: background questionnaires on health and fitness status, and a semi-structured interview. Each participant completed four questionnaires: (1) a Health and Demographics Questionnaire (Czaja et al., 2006), which assessed participant's overall health and collected background information including age, gender, race, and education as well as any vision, hearing, or mobility limitations; (2) a Rapid Assessment of Physical Activity Questionnaire, which assessed participant levels of physical activity; (3) a CHAMPS Physical Activities Questionnaire for Older Adults, which assessed the frequency and duration of various physical activities as completed by each participant; and (4) an Exercise Confidence Survey, which was a 9-item questionnaire developed to assess the effect of environmental barriers on maintaining physical activity (0 "not at all confident" to 10 "very confident").

The semi-structured interview script was designed to identify barriers, facilitators, and motivators to initiating or maintaining physical activity or exercise regimens as perceived by older adults. Each participant was asked about their current daily routine, types and frequency of both exercise and physical activity, intrinsic and extrinsic influences on them becoming or maintaining their level of physical activity, perceived challenges and workarounds to these activities, and any goals they set towards working out.

Following the informed consent each participant was asked to complete the first three surveys for a self-report of physical activity levels and routine exercise completion. Once the questionnaires were complete, participants were told that recording of the session would begin and the semi-structured interview script was followed. Upon finishing the semi-structured interviews, each participant was then asked to complete the Exercise Confidence Survey. Data collection was performed by trained graduate research assistants. This study protocol was approved by the ethical committee of the university.

### Data Analysis

Data from audio recordings were transcribed verbatim. Data analysis was guided by a method of deductive thematic analysis to identify themes within the data by intensively analyzing data by segments of text (Boyatzis, 1998). A coding scheme was developed from categories of barriers, facilitators, and motivators to older adults engaging in and maintaining physical activity and exercise. Each transcript was segmented into units of text based on high-level categories adapted from literature on behavior change theory, physical activity promotion, and motivation (Greaney et al., 2008; Grossman & Stewart, 2003; Jancey et al., 2008; Park et al., 2014; Sullivan & Lachman, 2016; White et al., 2012). A segment was defined by a participant's description of frequency, duration, or context, of a physical activity construct, and ended with the mention of a new high-level category. During the initial segmentation, additional codes were derived from transcript data and included in the coding scheme. In addition to analyzing segments based on the coding scheme, data were also analyzed for descriptive quotes regarding ideal exercise experience with regard to types of activities and preference to exercise alone or in groups.

Two researchers coded a sample set of interview transcripts to obtain inter-coder percent agreement as an index of reliability of the coding scheme. Two transcripts representing one frequent and one infrequent exerciser were chosen and coded independently. Inter-coder agreement on code definitions was calculated using Cohen's Kappa (McHugh, 2012). The minimum acceptable agreement was set at .85, or 85%, or above by the two researchers.

The first round of independent coding yielded a percent agreement of 75%. Initial disagreements were discussed with a third researcher, and definitions of codes were refined for clarity. The sample transcripts were then re-coded and found to have an 89% agreement between the two researchers. To ensure that this agreement was reached due to efficient codes and not familiarity with the initial sample of transcripts, two new transcripts were chosen and again coded for percent agreement. This third round of coding yielded an 86% agreement. Remaining transcripts were then divided equally between the two researchers for independent coding, stratifying for equal distribution of frequent and infrequent exercisers.

Following coding, a frequency analysis was conducted to quantify the prevalence of each theme within the data. This analysis was used to discern the quantitative counts of participants discussing a particular valence. A chi-square analysis was performed to identify statistically significant difference ( $p < 0.05$ ) among the distribution of themes in a category, as well as across groups of frequent and infrequent exercisers.

## Results

### Participant Characteristics

Among the overall sample for this analysis 56.3% were married, and 81.2% lived with a significant other or family member. Participants were recruited specifically for their level of physical activity and exercise, with 25% reporting being physically active one day or less per week. Demographics of the sixteen older adult participants are presented in Table 2 by frequent exercisers, infrequent exercisers, and the overall sample.

**Table 2. Descriptive statistics**

<b>Characteristic</b>	<b>Frequent Exercisers <i>n</i> (%)</b>	<b>Infrequent Exercisers <i>n</i> (%)</b>	<b>All Participants <i>N</i> (%)</b>
Age (M ± SD) [Range]	75 ± 6 [67-84]	73 ± 6 [66-84]	74 ± 4.6 [66-84]
Education (%)			
Less than High School Grad	0	1 (12.5)	1 (6.3)
Vocational Training	0	2 (25)	2 (12.5)
Some College/Associate's	2 (25)	1 (12.5)	3 (18.8)
Bachelor's Degree	4 (50)	2 (25)	6 (37.5)
Master's Degree	1 (12.5)	2 (25)	3 (18.8)
Doctoral Degree	1 (12.5)	0	1 (6.3)
Ethnicity (%)			
White Non-Hispanic	7 (87.5)	3 (37.5)	10 (62.5)
Black Non-Hispanic	1 (12.5)	5 (62.5)	6 (37.5)
Marital Status (%)			
Single	1 (12.5)	0	1 (6.3)
Married	5 (62.5)	4 (50)	9 (56.3)
Divorced/Separated	1 (12.5)	2 (25)	3 (18.8)
Widowed	1 (12.5)	2 (25)	3 (18.8)
Living Environment (%)			
Living Alone	1 (12.5)	2 (25)	3 (18.8)
Living w Immediate Family	5 (62.5)	5 (62.5)	10 (62.5)
Living w Adult Children	0	1 (12.5)	1 (6.3)
Living w Extended Family	2 (25)	0	2 (12.5)

### Physical Activity Behaviors

Interview data were analyzed for five pre-determined themes relevant to understanding older adult's physical activity behaviors: activities considered physical activity; perceived benefits of physical activity; physical activity barriers; motivators to initiate and maintain physical activity; and facilitators to exercise and be physically active. From this analysis, the theme of goal-setting techniques emerged as a relevant theme. A description of each theme as determined by the researchers is presented in Table 3. Within each theme, we identified sub-themes or categories, which were analyzed for their prevalence and frequency of discussion.

**Table 3. Theme definitions**

<b>Theme</b>	<b>Description</b>
Perceived benefits of physical activity	Positive physiological or social attributes stemming from being physically active
Physical activity barriers	Any extrinsic or intrinsic circumstance or obstacle that prevents activity engagement
Motivators to initiate and maintain physical activity	Influential factors that encourage activity engagement
Facilitators to exercise and be physically active	Environmental aids or supports that helped an individual to engage in an activity
Goal-setting techniques	Methods of setting and tracking goals

### *Types of Physical Activity and Exercise Among Older Adults*

In addition to group and individual fitness activities, participants also reported several types of everyday activities as part of their physical activity. There was no statistical significant difference found between these two groups due to sample size, however results are grouped by frequent and infrequent exercisers for reference. Regarding physical



activity performed, activities such as gardening, singing or playing instruments in a church choir, or household cleaning were reported as vigorous activities done on a consistent basis, and considered to be things that kept participants active. Similar distributions were seen between groups of the types of physical activity and exercise reported, where exercise activities such as yoga and chair aerobics as well as walking, running, and cycling showed more of a trend among frequent than infrequent exercisers. Frequent exercisers also showed more of a trend to consider their hobbies as physical activity, whereas infrequent exercisers showed more of a trend to consider household chores and errands as physical activity. Table 4 shows the distribution of type of physical activity and exercise as reported by participants.

**Table 4. Frequency of types of physical activity and exercise behaviors reported**

	<b>Frequent Exercisers <i>n</i> (%)</b>	<b>Infrequent Exercisers <i>n</i> (%)</b>	<b>All Participants <i>N</i> (%)</b>
<b>Physical Activity</b>			
Household chores and errands	15 (60)	23 (77)	38 (69)
Hobbies that involve standing/movement	7 (28)	3 (10)	10 (18)
Leisure walking	3 (12)	4 (13)	7 (13)
<b>Exercise</b>			
SilverSneakers	2 (6)	1 (8)	3 (7)
Dancing (Zumba, classes)	1 (3)	2 (15)	3 (7)
Swimming/water exercises	2 (6)	1 (8)	3 (7)
Stretching/yoga/chair aerobics	4 (13)	0 (0)	4 (9)
Outdoor structured walking/running/cycling	8 (25)	2 (15)	10 (22)
Indoor walking/running on treadmill	3 (9)	1 (8)	4 (9)
Strength and mobility classes	8 (25)	4 (31)	12 (27)
Team sports (tennis, basketball, etc.)	4 (13)	1 (8)	5 (11)
No formal exercise	0 (0)	1 (8)	1 (2)

### *Perceived Benefits of Physical Activity and Exercise*

Participants mentioned several perceived benefits to engaging in physical activity and exercise as shown in Table 5. The most commonly mentioned perceived benefit was improving physical health such as getting back in shape, improving stamina, or increasing strength. This category comprised over half (54%) of all the perceived benefits discussed by infrequent exercisers. Other benefits included eliciting feelings of joy, helping with management of chronic health conditions and age-related deficits, and improved mental health (i.e., reduction of stress and depression). Although there was no statistically significant difference between the two groups of frequent and infrequent exercisers, it is relevant to note that infrequent exercisers saw more benefit in physical activity for improving physical health.

**Table 5. Frequency of perceived benefits of physical activity and exercise**

	<b>Frequent Exercisers <i>n</i> (%)</b>	<b>Infrequent Exercisers <i>n</i> (%)</b>	<b>All Participants <i>N</i> (%)</b>
Improves physical health (getting in shape, stamina, strength)	10 (36)	7 (54)	17 (41)
Improves mental health (relieves stress and depression)	8 (29)	3 (23)	11 (27)
Helps with chronic and age-related health conditions	6 (21)	2 (15)	8 (20)
Enjoyment or “feeling better”	4 (14)	1 (8)	5 (12)

### *Barriers to Initiating and Maintaining Physical Activity and Exercise*

*Extrinsic Barriers.* By and large the most frequently mentioned barrier to engaging in physical activity for both infrequent (61% of barriers mentioned) and frequent (72% of barriers mentioned) exercisers was inclement weather. This factor was consistently named

as something that prevented participants from being active or reduced the frequency of their activity. One participant commented “I would probably use it as an excuse, [be]cause it’s raining outside”. Others mentioned their neighborhood being non-conducive: “I don’t think any [sidewalk/roadway] leveling was done... so it’s pretty much dangerous to bike or even walk as a matter of fact”. Additionally, a lack of access to fitness facilities such as gyms or recreation centers was reported as 28% of the extrinsic barriers reported among frequent exercisers while this barrier was only reported at 14% among infrequent exercisers. Transportation to fitness facilities was also mentioned as a reasoning behind inability to access these centers, with proximity and cost of membership emerging as the next most prevalent reasons participants felt they could not access fitness facilities.

*Intrinsic Barriers.* The most commonly mentioned intrinsic barrier across both groups was physical limitations that made it difficult to be active (50% of the barriers mentioned among frequent exercisers, 27% of those mentioned among infrequent exercisers). This type of barrier was especially prevalent among frequent exercisers, comprising half of the total intrinsic barriers mentioned for this subgroup. Other barriers mentioned included feeling fatigued or unmotivated, schedule conflicts, disliking an activity or having trouble keeping up with the pace, and lacking people to engage in activity with.

Aside from physical limitations, lack of motivation and activities that are conducive to the needs and interests of older adults was reported somewhat frequently among all participants (46% of intrinsic barriers reported). Participants stated that feeling tired or having to be active alone would cause them to not want to engage in physical activity, or

as a reason they might discontinue an activity prematurely. When asked about their confidence if they had to work out alone, one participant commented, “If I’m exercising by myself, maybe something will come up and I’ll just stop. I find it easier to work out with somebody or a group. I’m more motivated that way”.

#### *Motivators to Initiating and Maintaining Physical Activity and Exercise*

Motivators for becoming physically active were divided into intrinsic motivators (e.g., enjoyment, wish to improve health) and extrinsic motivators (e.g., printed materials and other forms of media). Intrinsic motivators mentioned by participants included enjoyment elicited from being active (35%), the convenience of the activity to one’s schedule (15%), and the habit of being active (5%). One of the more frequently reported intrinsic motivators was the knowledge of the importance of activity for physical and mental health (45%). See Table 6. Participants reported that physical activity is something they know they need to do to avoid weight gain and delay future chronic illnesses such as heart or joint issues.

**Table 6. Frequency of intrinsic and extrinsic motivators to initiate physical activity and exercise**

	<b>Frequent Exercisers <i>n</i> (%)</b>	<b>Infrequent Exercisers <i>n</i> (%)</b>	<b>All Participants <i>N</i> (%)</b>
<b>Intrinsic Motivators</b>			
Understanding of mental/physical health benefits	5 (42)	4 (50)	9 (45)
Perceived enjoyment of the activity	4 (33)	3 (38)	7 (35)
Convenient to schedule	2 (17)	1 (13)	3 (15)
Experience being active in the past	1 (8)	0 (0)	1 (5)
<b>Extrinsic Motivators</b>			
Printed material or media	4 (44.5)	7 (46)	11 (46)
Peers/friends/family (spouse, children)	4 (44.5)	6 (40)	10 (42)
Doctor/medical professional	1 (11)	1 (7)	2 (8)
Characteristics of the activity (instructor, pace)	0 (0)	1 (7)	1 (4)

Extrinsic motivators were mentioned as things from a participant's physical or social environment that encouraged them to initiate physical activity or exercise. Among the extrinsic motivators reported from the participant sample, printed material or media was reported more commonly (46% among motivators reported from frequent and infrequent exercisers). Frequent exercisers expressed that seeing things in fitness magazines, or health ads on TV or on physical posters in their community often encouraged them to begin physical activity or exercise. For example, one participant said, "I always look at fitness magazines, I look at the tennis magazine. I see commercials on TV to keep your body well and mind healthy, that definitely influences my thought process". Infrequent exercisers however did not report the influence of printed materials. Another common extrinsic motivator was the support or influence of peers, friends, and family members. Participants discussed this as something that was often a major reason that they desired or were able to be physically active. One person stated "I have a couple of ladies

that I walk with. They push me”. Engaging in group activities with a structured group or a spouse was often reported, and some participants mentioned the influence of a family member that was also physically active as being an influence in their own physical activity behaviors. The influence of doctors or other medical professionals (physical therapists, nurses) was also named as a motivator to becoming physically active.

**Table 7. Frequency of intrinsic and extrinsic motivators to maintain physical activity and exercise**

	<b>Frequent Exercisers <i>n</i> (%)</b>	<b>Infrequent Exercisers <i>n</i> (%)</b>	<b>All Participants <i>N</i> (%)</b>
<b>Intrinsic Motivators</b>			
Understanding of mental/physical health benefits	18 (64)	9 (69)	27 (66)
Enjoyment of the activity	10 (36)	4 (31)	14 (34)
<b>Extrinsic Motivators</b>			
Peers/friends/family (spouse, children)	16 (64)	5 (72)	21 (66)
Doctors/medical professional	4 (16)	1 (14)	5 (16)
Printed material or media	3 (12)	0 (0)	3 (9)
Instructor of activity	2 (8)	1 (14)	3 (9)

Although similar distributions were seen among the intrinsic and extrinsic motivators to maintain physical activity and exercise (Table 7), there was noticeable trend in more mention of influence from family, friends and peers among frequent exercisers (64%).

#### *Facilitators to Physical Activity and Exercise*

The most variation between infrequent and frequent exercisers was in what facilitated their exercising or being physically active. Whereas frequent exercisers reported that engaging in activity was more likely if they had the necessary environmental

conditions and support (46% of facilitators reported), infrequent exercisers reported facilitators that aligned with the ability to personalize their workout (e.g., being able to go at one's own pace or at a particular time of day) more frequently (40%). Other facilitators included an individual's health at the time of activity, support of peers to engage in the activity with, characteristics of the instructor of any activity, and prior experience and familiarity with the activity (Table 8).

**Table 8. Frequency of discussed facilitators of physical activity and exercise**

	<b>Frequent Exercisers</b> <i>n</i> (%)	<b>Infrequent Exercisers</b> <i>n</i> (%)	<b>All Participants</b> <i>N</i> (%)
Environmental conditions and supports	5 (46)	4 (20)	9 (33)
Support from instructor or peers	5 (26)	6 (30)	11 (28)
Ability to customize and personalize workout (pace, time)	7 (17)	8 (40)	15 (28)
Prior experience with activity	1 (5)	1 (5)	2 (5)
Health conditions	1 (5)	1 (5)	2 (5)

### Goal-Setting Techniques

More than half of participants (60%) reported that they did set physical activity and exercise goals, both short and long-term. Among the participants who did set specific physical activity and exercise goals, 75% reported tracking these goals manually through a fitness/workout journal, an exercise calendar, or by keeping a log or mental note of their weight. Interestingly, 50% of all participants interviewed reported that they did not track their progress towards their goals.

The most frequently mentioned goal (56% of all participants) was to increase and maintain consistency with the frequency of physical activity. Participants mentioned wanting to be physically active so they would be in better shape, wanting to try a specific

activity, or wanting to reach a specific level of performance within an existing activity, with little difference in distribution among frequent and infrequent exercisers. Starting a new physical activity or exercise was mentioned as a goal among infrequent exercisers (17%) while this goal was not mentioned among frequent exercisers (See Table 9).

**Table 9. Frequency of physical activity and exercise goals discussed**

	<b>Frequent Exercisers <i>n</i> (%)</b>	<b>Infrequent Exercisers <i>n</i> (%)</b>	<b>All Participants <i>N</i> (%)</b>
Increase frequency/ be more consistent	7 (54)	7 (58)	14 (56)
Hit a target performance time	2 (15)	1 (8)	3 (12)
Losing weight/get in shape	4 (31)	2 (17)	6 (24)
Start a specific activity	0 (0)	2 (17)	2 (8)

## **Discussion**

This analysis revealed insight into the psychological constructs associated with older adults' initiating and maintaining physical activity or exercise. Examining these constructs in two stages of activity engagement identified motivational factors relevant to two key stages of behavior change outlined by the Transtheoretical Model of behavior change (Cheung et al., 2007): initiating the behavior and maintaining the behavior. Although the sample for this study was small and limited to older adults from the metro-Atlanta area, these findings have implications for research on aging and design of technological interventions aimed at increasing physical activity and exercise among older adults.

### Understanding Older Adults' Motivations for Physical Activity and Exercise

These results highlight several constructs associated with physical activity behaviors and identifies several key motivating factors of physical activity as expressed by



older adults, addressing RQ1. Findings from the frequency analysis indicate that there is little difference in the prevalence of intrinsic versus extrinsic motivators among older adults. There was however more of a spread among extrinsic motivators to include several types of social and peer influence and advertisement and endorsement materials. Similar to previous research findings (Bethancourt et al., 2014; Grossman & Stewart, 2003), participants expressed feeling motivated by the influence and encouragement of their friends and family, relevant images seen in media or fitness literature, and suggestions from doctors or other medical personnel. These findings also indicate that a key source of motivation for older adults lies in their understanding of a direct correlation between physical activity performance and the health benefits that result from such performance. Participants expressed that by being intentionally active daily and maintaining a certain level of activity they were able to manage or prevent certain chronic health conditions, stating this as something that motivated them to continue activity. Oftentimes motivators reported by participants were also considered to be facilitators of the activity, supporting an individual in their efforts of physical activity performance. This analysis identified enjoyment, adaptation and personalization, and social support as examples of both motivators and facilitators that would be particularly beneficial to leverage in physical activity interventions for older adults.

Results indicate that participants felt there were certain motivators and facilitators relevant to initiating physical activity and others more relevant to maintaining existing levels of physical activity. Thus, these constructs can be framed into two stages of behavior change (initiating physical activity and maintaining physical activity) to explore relevant

interventions. Among both frequent and infrequent exercisers, constructs such as knowledge of health benefits, social influence, and proper instruction on how to perform an activity or exercise were expressed as motivating to initiate physical activity. To maintain levels of physical activity, participants reported being motivated and supported by such things as enjoyable activity instructors, being able to perform activities at their own pace, and understanding their progress towards end goals. Additionally, structuring activities that are relevant to older adults that are at the same time engaging (fun, enjoyable) and progressively challenging would benefit both the initiation and maintenance stage of physical activity.

#### Redefining Moderate to Vigorous Physical Activity

One of the contributions of this analysis is re-framing the way in which moderate to vigorous physical activities are categorized in reference to older adults. Our interviews initially sought to examine the determinants of physical activity and exercise as defined by structured activities done for recreation or sport. Most often, studies that examine fitness in older adulthood consider walking, aerobics, yoga, or other group exercises as a measure of moderate to vigorous activity levels, neglecting the inclusion of non-structured activities as engagement in physical activity at this intensity level. However, findings indicated that participants considered everyday activities of daily living to constitute moderate to vigorous physical activities at their age, due to the physical exertion required in their performance. Redefining this activity to encompass various household activities that elicit physical movement and exertion also provides a new perspective in structuring interventions to encourage or facilitate physical activity in older adulthood.

Interventions that leverage a broader range of physical activities as a foundation for other physical movements and routines, or those that are able to track these activities and provide performance feedback to older adults may be more effective. Framing physical activity in this way may also shift from a negative narrative of older adults seeing a deficit in physical activity performance, and focus on enhancing the physical activities that this population deem to be meaningful. Lack of knowledge and intimidation in performing traditional exercises are among the more common reasons older adults avoid engaging in physical activity and exercise (Bethancourt et al., 2014). Incorporating activities that are considered more familiar and lower risk may have positive impact on activity and exercise adherence, attitudes towards physical activity and exercise, and individual self-efficacy.

#### Implications for Mobile Health Technology Design

Consistent with previous findings (Bjornsdottir et al., 2012; Park et al., 2014), results from this analysis identified both psychological and social factors associated with older adults engaging in physical activity. This analysis frames these factors into two stages of engagement, and includes an in-depth look into the characteristics of the activities that older adults consider physical activity or exercise. This analysis also reinforces the need for extrinsic motivations as an approach to encouraging physical activity. My analysis contributes additional factors such as understanding the health benefits of physical activity, and the ability to personalize and customize the activity itself as additional strategies that can be used to encourage physical activity engagement. These factors can be translated into design requirements for mobile health technologies to promote physical activities and exercise among older adults.

## **Conclusion**

In conclusion, findings indicate that older adults' physical activity behaviors are motivated in two stages of physical activity; initiation and maintenance. In-depth semi-structured interviews and a deductive thematic analysis identified key motivational factors associated with older adults being active, such as facilitation of social influence, awareness and knowledge of health benefits correlated with physical activity performance, and tangible and measurable short-term goals. The ways in which physical activity is defined from the perspective of older adults was examined, and a more inclusive metric of physical activity performance was suggested. As a translation to the development of mobile health technologies for physical activity promotion, the findings provide guidance for the design, which stem from these motivational factors. Future quantitative analysis should measure if the implementation of these factors in the design of mobile health technologies has a significant effect in increasing physical activity among older adults.

# **CHAPTER 5: IDENTIFYING KEY MOTIVATIONAL DESIGN STRATEGIES FOR OLDER ADULTS' ENGAGEMENT W/ MOBILE HEALTH TECHNOLOGIES**

## **Overview**

Recent work in the area of designing mobile apps for health-related behavior change has shown the benefits of incorporating theoretical constructs into the design of mobile apps for health and fitness. Among thousands of existing apps targeting health-related behavior change, those that are designed based on theoretical constructs have potential to see more meaningful outcomes for users, yielding increases in individual physical activity levels. Existing taxonomies identify various behavior change techniques which have been developed from established behavior science theories and integrated into the design features of mobile health and fitness apps. While iterations of these taxonomies appear to address the constructs of physical activity behaviors, few of these newer taxonomies have focused on incorporating inclusive behavior change techniques for underserved populations. Specifically, there is opportunity to derive motivational design strategies and behavior change techniques that are inclusive of the needs and motivations of older adults, as this population is often neglected in technology design. Incorporating the needs of this population into the techniques used to design mobile health technologies is significant to the design and aging research communities as incorporating these needs could lead to a more widespread adoption of these technologies, increasing the potential of health benefits associated with use.

In order to identify relevant motivational design strategies and behavior change techniques, I have analyzed existing taxonomies and frameworks of design features against the findings of the qualitative interview data discussed in Study 1 (see Chapter 4) to identify strategies and techniques that would be inclusive of older adults. Here existing strategies and techniques were assessed for their ability to address the barriers, facilitators and motivators as stated by older adults, resulting in the identification of techniques that speak to the technology interaction needs of older adults. The review and proposed design strategies discussed here address RQ2, and help to define relevant features of mobile health and fitness apps that would positively impact the older adult population.

### **Existing Taxonomies and Frameworks of Behavior Change Features**

Several existing taxonomies, frameworks and models frame the approach of designing technologies and products for behavior change. Many of these frameworks or taxonomies are grounded in behavior change theory, presenting techniques that translate into system features which guide designers and researchers in developing products and technologies that are intended to target a specific behavior.

The Persuasive Systems Design (PSD) framework developed by Oinas-Kukkonen and Harjumaa (2009) organized the persuasive design techniques most commonly used into four major categories: primary task support (design techniques that support the user in carrying out the intended task by making it seem easier to do); dialogue support (some degree of system feedback via verbal information or other summaries); system credibility (leverages credibility via trusted authorities such as medical professionals or government officials); and social support (designing systems so to motivate users through social

influences such as comparison or competition). According to this framework, persuasive technologies are designed with features tied to a particular technique that helps to elicit attitude and behavior change towards an activity. For example, ‘rehearsal’ is identified as a behavior change technique in the PSD framework, and is seen illustrated by showing a user the mechanics of performing an exercise and suggesting practice of that activity following a video or instructor’s command in an app.

A majority of work in the area of taxonomies of behavior change techniques include iterations of the Abraham and Michie (2008) taxonomy developed for physical activity and dieting behaviors. This taxonomy presents 26 items used to guide physical activity and dieting interventions with techniques such as prompting specific goal setting and providing instruction. Other iterations of this taxonomy include the CALO-RE taxonomy (Michie et al., 2011), and Weiser’s taxonomy of motivational affordances for meaningful gamified and persuasive technologies (Weiser et al., 2015), both of which have identified areas where existing taxonomies and frameworks have either overlap or lack of clarity in certain techniques. While these revisions have been an improvement in conceptualizing behavior change in the area of physical activity, exercise, and general health and wellness, there is a need for a more inclusive set of behavior change techniques that incorporate the needs and functional abilities of older adults.

There is consistency across several existing taxonomies and frameworks that is helpful to identify in aggregating and developing new frameworks that do not redefine techniques deemed fundamental to health-related behavior change. Most notably, coaching, goal support, and social influence appear as either a larger strategy or a more

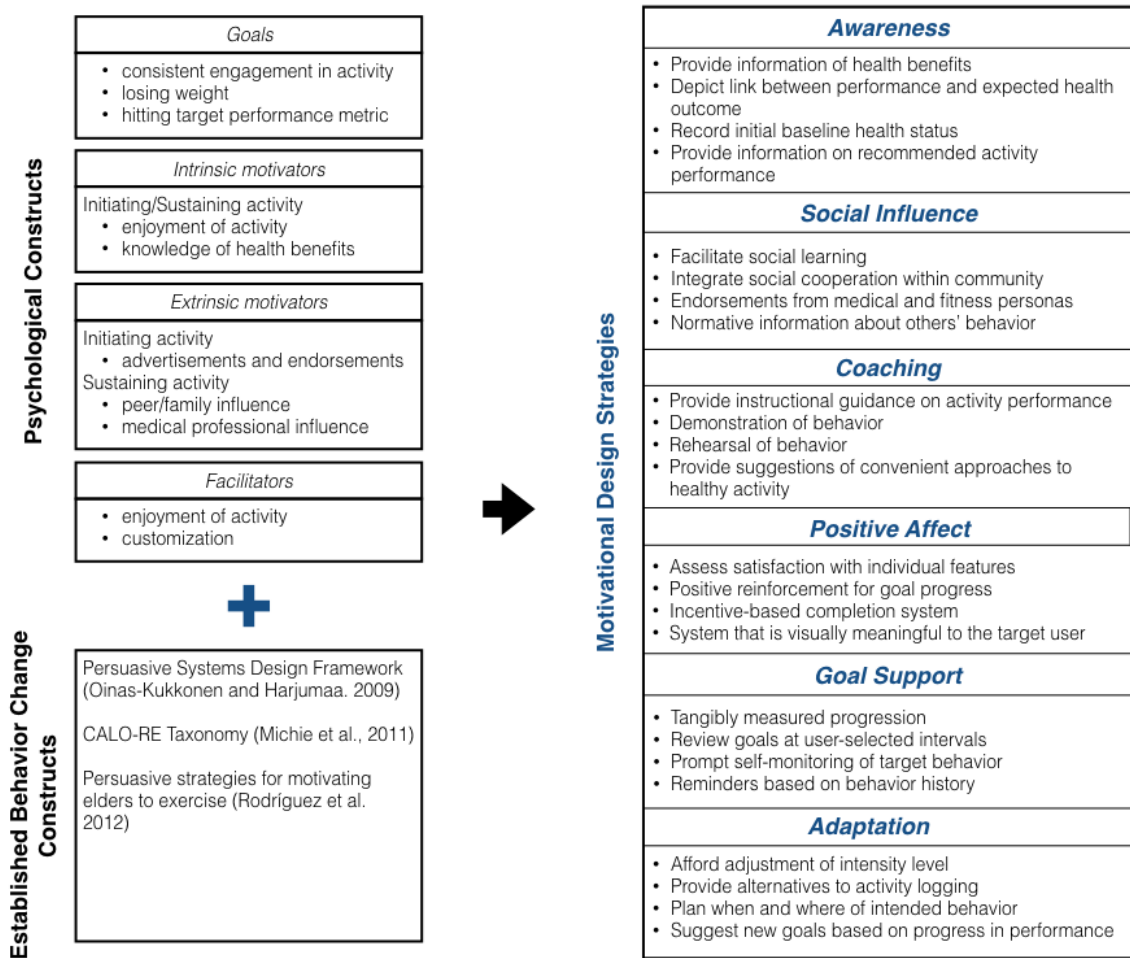
tangible behavior change technique in most taxonomies and frameworks to date. The taxonomy presented in Michie et al. (2011) presents as the most exhaustive in terms of behavior change techniques included, and has specifically been refined for clarity and relevance to behavior change of physical activity behaviors. This taxonomy also presents more concrete behavior change techniques when compared to other taxonomies and frameworks, which is beneficial to the development of mobile health technologies in this space. The Persuasive Systems Design framework presents more techniques that speak to social support and the influence that endorsements and credibility have on behavior change. This framework also introduces behavior change techniques that speak to the positive reinforcement of a behavior and the notion that this type of reinforcement may also be encouraging to behavior change. Despite an expansive culmination of strategies and techniques presented by these taxonomies and frameworks, there is a need to derive behavior change techniques that better incorporate the needs and relevant psychological constructs as expressed by older adults.

### **Motivational Design Strategies for Health Technologies for Older Adults**

Existing taxonomies and frameworks were examined for redundancy and clarity of behavior change techniques, application of a technique to health-related behaviors, and inclusion of prevalent psychological constructs presented in Study 1. From this examination, I have aggregated relevant behavior change techniques and defined six motivational design strategies to encourage technology integration and sustained engagement of mobile health and fitness apps among older adults. Figure 1 depicts the aggregation of Study 1 findings and existing behavior change strategies and techniques.



Strategies have been extracted primarily from the qualitative analysis conducted in Study 1 and compared to existing frameworks and taxonomies for overlap. Behavior change techniques from existing frameworks and taxonomies were reviewed for redundancy and new techniques were added that captured constructs which emerged from Study 1 that were not already present in an existing framework. The new set of motivational design strategies include: awareness, social influence, coaching, positive affect, goal support, and adaptation. Each strategy is defined below along with the evidence-base for its derivation, as well as examples of behavior change techniques associated with the strategy.



**Figure 1. Motivational design strategies and associated behavior change techniques**

*Awareness: Provide Information on Health Benefits of Everyday Activities*

One of the key themes uncovered in the qualitative analysis in Study 1 was the breadth of types of physical activity that older adults engaged in, including many everyday activities. Existing mobile health technologies encourage users' engagement in traditional exercise activities (e.g., running, walking, swimming). However, it may be more effective to acknowledge and track the everyday activities that older adults are already performing. For example, participants expressed enjoying gardening, doing housework, volunteering, and engaging in religious activities. Thus, a potentially effective intervention approach may

be to design mobile health technologies that quantify the physical health benefits of gardening and housework and inform users of the ways these activities contribute to physical and mental health.

The benefit of reduced depression and anxiety was commonly mentioned as a motivation to be physically active among participants of the qualitative interviews, thus there is also value in acknowledging potential mental health benefits of physical activity within the information display of technologies. Long-term use of health technologies and engagement in physical activities is supported by the knowledge of the health-related benefits associated with their actions (Meyer et al., 2016). Thus, technologies that encourage older adults to recognize the health benefits in the everyday activities that they already perform (i.e. volunteering, religious activities) may be more successful in adoption and promotion of physical activity than those that introduce new activities that are considered intimidating or not relevant to the older adult population.

Examples of behavior change techniques that illustrate awareness of the benefits of physical activity might include showing a direct correlation between one's physical activity and their heart rate, whether through analytic data of numbers or scores on a graph, or by messaging of how doing a particular activity might impact one's health in a specific area. Features could include calorie calculators, information sections, or messages of health benefits.

#### *Social Influence: Support Interpersonal Engagement through Familiar Social Groups*

Findings from Study 1 indicate that social influence is both a major motivator and facilitator to older adults initiating and sustaining physical activity regimens. Similar

studies have found that social influence is correlated with a significant impact on physical activity behaviors due to the statistics of individuals that express preference in working out with others (White et al., 2012). Encouraging participation in group exercise classes and neighborhood fitness programs has long been a community-based approach to promoting physical activity among the older adult population (Bock et al., 2014). Additionally, social influence is listed as a prominent extrinsic factor of technology engagement and behavior change (Karanam et al., 2014; Murnane et al., 2015; Rodriguez et al., 2012; Voth et al., 2016). From a mobile health technology standpoint, this type of social interaction is often encouraged by connecting users to existing social networks such as Facebook, Google+, or a user's contact list. Although older users are beginning to leverage these platforms more frequently (Perrin, 2015), findings from the qualitative interviews indicated that older adults still rely on the physical interaction of in-person contact to engage in physical activity due to the familiarity of instructors or peers also engaging in the activity. As a strategy to successfully encourage physical activity or other health-related behaviors among this population, researchers and designers should develop mobile health technologies that incorporate familiar social groups and networks of peers into the performance of the activity itself.

Social influence features might include connecting users to new groups that are also performing similar physical activities, allowing users to track and communicate activities simultaneously with close friends and family members that may be in different geographical regions, or implementing physical activity challenges among groups of friends through a technology.

### *Coaching:*

Coaching helps an intended user understand how to perform an intended activity through instruction and rehearsal. According to Michie et al. (2011) and Oinas-Kukkonen and Harjumaa (2009), coaching is an important strategy for behavior change among individuals who are novice to a technology or activity. More recent taxonomies suggest that coaching for behavior change goes beyond just instructing a user to perform a particular behavior, but also instructing the user how to perform that behavior through rehearsal and demonstrations. Thus, rehearsal and demonstrating the behavior are valuable behavior change techniques to encouraging physical activity and exercise behaviors. In addition, data from Study 1 suggests providing suggestions of convenient times and locations of an activity as another supportive behavior change technique for encouraging and promoting physical activity behaviors. Detailing the ‘when’ and ‘how’ of new activities may support users of a technology to see where the activity fits into their schedule, and reduce the barrier of scheduling or even facility access if activities are promoted that can be done as a part of tasks the individual is already doing. For example, a beneficial app feature for coaching may be notifying users that taking the stairs at a doctor’s office or other appointment could help earn more steps in a day than taking an elevator.

### *Positive Affect: Eliciting Enjoyment and User Satisfaction*

Positive affect is defined as the extent to which an individual experiences positive association with an activity such as joy, interest, or alertness (Miller, 2011). Positive affect as a motivational design strategy frames the enjoyment and user satisfaction of the app

though facilitating relevance and ultimately interest with the user. Incorporating features that encourage a positive correlation with using the app and being physically active, as well as assessing a user's satisfaction with the functionality of the app are key to this strategy. This factor emerged from the interview data as a crucial construct for older adults to sustain their engagement in physical activity. Findings from Study 1 indicate that many participants felt an activity must be appealing and fun in order for them to stay engaged with it over time. Similarly, Kaasinen et al. (2011) suggest that perceived value is an overall contributing factor to system use, and represents an addition to the TAM. As such, attractiveness, fun, and excitement have been found to contribute to a user's perceived value of a technology and the interaction with that technology (Chang et al., 2012). Supporting this construct would resultantly encourage sustained use of a health and fitness app.

Examples of behavior change techniques associated with positive affect would be incentives and positive reinforcement for physical activity performance. An additional behavior change technique that is not present in existing taxonomies is the concept of encouraging a user through relevant images and visuals that are appealing to their demographic. Throughout these interviews, participants commented on the ability to see their likeness in motivating material as something that could be a determinant of whether or not that material was deemed truly motivational. Encouraging physical activity among the older adult population with images that are inclusively representative of older adults or neutral through ageless characters or icons may also support engagement with an activity and the technology that encourages that activity.

### *Goal Support: Support Tangibly Measured Goals and Objectives*

Setting and measuring attainable goals has been shown to be linked to higher self-efficacy when considering physical activity behaviors. Encouraging users of health technologies to set tangible and obtainable goals and objectives has the potential to increase the user's engagement with a technology by appealing to a user's perceived usefulness of the system. This strategy is currently evident in existing frameworks such as the PSD framework and the Michie taxonomy. Additionally, participants in Study 1 reported that it was important to them to know how well they were meeting their self-defined goals whether those goals were a pre-determined amount of weight loss, or a performance metric during physical activity. Providing users with immediate feedback on their progress and the ability to map out future goals that are in line with their perceived capabilities may help to increase engagement in the activity and with the technology itself.

The implementation of goal support in mobile health and fitness app features could include allowing a user to define an activity goal and measuring and displaying progress towards that goal at user-specified increments. For example, if the goal of an app is to increase walking as a measure of physical activity, it is most relevant to evaluate and encourage this construct by measures that directly relate to walking such as minutes walking or distance.

### *Adaptation: Allotting for Personalization and Customization*

Personalization of activities and exercises emerged as a consistent theme across frequent and infrequent exercisers throughout our interview analysis, and has been identified in several taxonomies and frameworks as a key feature to encourage behavior

change (Michie et al., 2011; Murnane et al., 2015; Oinas-Kukkonen & Harjumaa, 2009; Weiser et al., 2015). Findings from interviews in Study 1 indicate that older adults expressed things such as relevant music, adjustable pace, and conducive instruction as key facilitators which motivated them to be engaged in physical activity. Customization of activities presented as an overall concept as a determinant to continue engaging in that activity. One viable approach to increasing engagement with mobile health technologies among this population would be to allow adaptation and customization of not only the ways in which a user interacted with the technology (e.g., various modes of input, varying sizes in screen text or contrast), but also in the aspects of the activity itself that is being performed (e.g. pace of the activity), may be a. For example, introducing an exercise such as arm raises that can be done at various paces and in different environments (outdoors, in the living room) may help to alleviate older users feeling as though the activity is intimidating or not meant for them. Implementing such a consideration may help to engage a larger subset of the older adult population that may not be used to normally engaging in physical activity or exercise, with or without the use of technology. A full list of the proposed behavior change techniques are presented in Table 10.



**Table 10. Motivational design strategies and associated behavior change techniques**

<b>Design Strategy</b>	<b>Behavior Change Techniques</b>	<b>Examples of Design Elements and/or Features</b>
<b>Awareness</b>	<ul style="list-style-type: none"> <li>• Provide information of physical activity benefits <sup>(a)</sup></li> <li>• Depict link between performance and expected health outcome <sup>(a)</sup></li> <li>• Record initial baseline health status <sup>(c)</sup></li> <li>• Provide information on recommended activity performance <sup>(c)</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Tool tips or message popovers with information of physical activity benefits</li> <li>• Graphs or visualizations of calories burned by physical activity performed</li> <li>• Charts of daily recorded health status</li> <li>• Periodic message popovers of suggested exercises or physical activity</li> </ul>
<b>Social Influence</b>	<ul style="list-style-type: none"> <li>• Facilitate social learning <sup>(a,b)</sup></li> <li>• Integrate social cooperation within community <sup>(b)</sup></li> <li>• Endorsements from medical and fitness personas <sup>(b)</sup></li> <li>• Normative information about others' behavior <sup>(a,b)</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Sharing activity status with other users through journals or feeds</li> <li>• Message boards; graphic visualization of other users currently engaging in activity</li> <li>• Messaging from a user's doctor or trainer; quotes from medical/fitness personas</li> <li>• Images or visuals of other users being physical active</li> </ul>
<b>Coaching</b>	<ul style="list-style-type: none"> <li>• Provide instructional guidance on activity performance <sup>(a,b)</sup></li> <li>• Demonstration of behavior <sup>(b)</sup></li> <li>• Rehearsal of behavior <sup>(a,b)</sup></li> <li>• Provide suggestions of convenient approaches to healthy activity <sup>(a)</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Help section on activity performance</li> <li>• Video tutorials showing activity performance</li> <li>• Tool tips or message popovers displaying ways to perform physical activity in current environment</li> </ul>
<b>Positive Affect</b>	<ul style="list-style-type: none"> <li>• Assess satisfaction with individual features and activities <sup>(c)</sup></li> <li>• Positive reinforcement for goal progress <sup>(b)</sup></li> <li>• Incentive-based completion system <sup>(b)</sup></li> <li>• System that is visually meaningful to the target user <sup>(c)</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Assessments of new features; ability to like/dislike content displayed</li> <li>• App provides reinforcement through dialogue messages, a change in visual display or sounds when a user makes a positive progression towards their goals</li> <li>• Providing user with trophies, coins, or other virtual rewards when a goal is accomplished</li> <li>• Design and symbolism uses colors, contrast, larger font, and language appropriate for older adults</li> </ul>
<b>Goal Support</b>	<ul style="list-style-type: none"> <li>• Tangibly measured progression <sup>(a)</sup></li> <li>• Review goals at user-selected intervals <sup>(a)</sup></li> <li>• Prompt self-monitoring of target behavior <sup>(a,b)</sup></li> <li>• Reminders and goal suggestion based on behavior history <sup>(c)</sup></li> <li>• Allow user to set their own goals <sup>(a)</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Status bar or chart/graph to show current level of progress towards goal</li> <li>• Present user with status and level of progress via screen popover or notifications</li> <li>• Direct user to review status daily or weekly through screen alerts or notifications</li> <li>• Messaging or background notifications outside of app</li> <li>• Tool tips or message popovers with goal suggestions</li> </ul>

<b>Adaptation</b>	<ul style="list-style-type: none"> <li>• Afford adjustment of intensity level <sup>(c)</sup></li> <li>• Provide alternatives to activity logging <sup>(c)</sup></li> <li>• Allow users to define their own activities <sup>(c)</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Settings section that allows user to indicate experience level; sliders or digital input of pace</li> <li>• Catalog of physical activity courses</li> <li>• Background tracking of activity in addition to manual entry</li> <li>• Calendar scheduling for desired activities</li> </ul>
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Behavior Change Techniques denoted by (Michie et al., 2011)<sup>a</sup>; (Oinas-Kukkonen & Harjumaa, 2009)<sup>b</sup>; new technique<sup>c</sup>

## **CHAPTER 6: EXAMINING MOBILE FITNESS APPS FOR INCLUSIVE BEHAVIOR CHANGE TECHNIQUES**

### **Overview**

To date, mobile phone app stores (iTunes and Google Play) contain over 25,000 apps that target health and fitness. As new developers are putting out newer health and fitness apps, it remains a task to understand the quality of these apps and the presence of content that is actually considered effective to encouraging physical activity behaviors. Mobile health and fitness apps as behavior change interventions are more likely to be effective if they are grounded in health behavior theory and strategies and constructs that stem from this theory (King et al., 2013; King et al., 2016; Vankipuram et al., 2012; Voth et al., 2016). Data on how these apps differ in their strategies of physical activity motivation and promotion is relatively new (Matthews et al., 2016; Middelweerd et al., 2014), but findings from these studies do suggest a direct positive affect between apps that are grounded in behavior change theory and the change in physical activity outcomes (increase in active minutes or level of physical activity intensity performed). In order to evaluate the quality of these existing apps, researchers have performed content analyses to assess the elements or features used in the design and functionality of an app that relevantly speak to behavior change.

To contribute to the existing research in this area, I have examined existing apps for the presence of inclusive motivational design strategies and behavior change techniques. Findings from the semi-structured interviews conducted in Study 1 presented six

motivational design strategies, and 24 behavior change techniques (see Table 10) proposed to be effective in encouraging older adults' physical activity behaviors when implemented in design features of mobile health and fitness apps. Based on these strategies and techniques, I have evaluated existing mobile health and fitness apps across various platforms to determine the variation in strategies and techniques present. As a result of this evaluation, I have selected three apps to deploy as experimental conditions to test the hypothesis that apps representative of social and goal support will be most effective in changing physical activity behaviors among older adults.

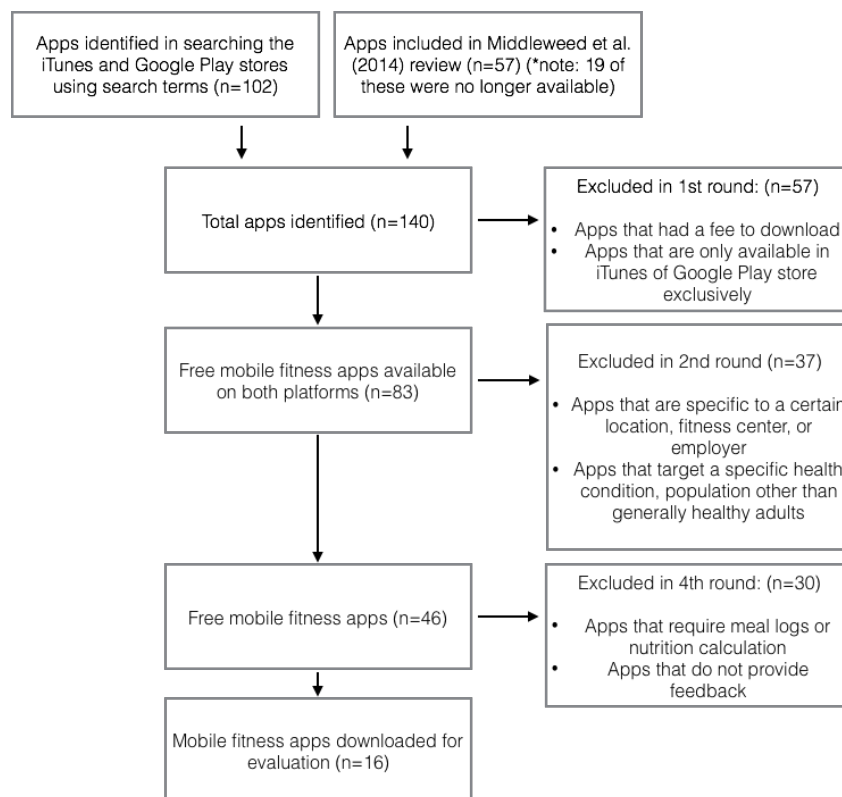
### **Content Analysis Method**

To examine the relevance and effectiveness of the identified motivational strategies, mobile fitness apps were evaluated based on each motivational strategy and behavior change technique. Mobile fitness apps were identified through a systematic search in the iTunes and Google Play stores. Due to the constant updating of platform stores, apps were searched directly from each store instead of existing databases found in literature (many apps identified in these databases were no longer available for download). This search was conducted in October and November of 2016.

#### **Eligibility and Search Criteria**

The search for mobile fitness apps included combinations of the terms “physical activity”, “fitness”, “fitness for elderly”, “fitness motivation”, and “coaching”. This review included apps that were available through both the iTunes and Google Play stores. Apps were filtered for those that: (i) have English as the primary language, (ii) are free to

download, (iii) promote physical activity only (no diet/nutrition component), (iv) primarily target generally healthy adults (those that are for a specific illness or condition were excluded), (v) provide individually tailored feedback, (vi) do not require the use of a specific activity tracker or additional hardware, and (vii) include walking and running activities to have comparable activities. Apps that were not able to be opened or registered for were also excluded. The screening procedure followed can be seen in below in Figure 2. Only apps that met the inclusion criteria were selected for evaluation. As such 16 apps were selected for further screening and assessment of behavior change techniques.



**Figure 2. Mobile fitness app screening process**

### Coding and Scoring

Following this screening, each app was installed on a researcher's device and used to establish an adequate understanding of the app features. Apps were then coded based on the presence of behavior change techniques proposed to be more inclusive of the motivators and facilitators of older adults' physical activity behaviors (see Chapter 4). A small sample of four apps were reviewed by three reviewers independently to establish agreement. During this initial review, reviewers evaluated apps for their presence of each behavior change technique and assigned an overall score to that app (0-24) representing the number of behavior change techniques identified. Reviewers then discussed the results of the initial sample evaluation to clarify definitions of techniques and any differences in interpretation. After agreement was established (96%), reviewers each reviewed 4-5 apps to determine a final score of behavior change techniques present.

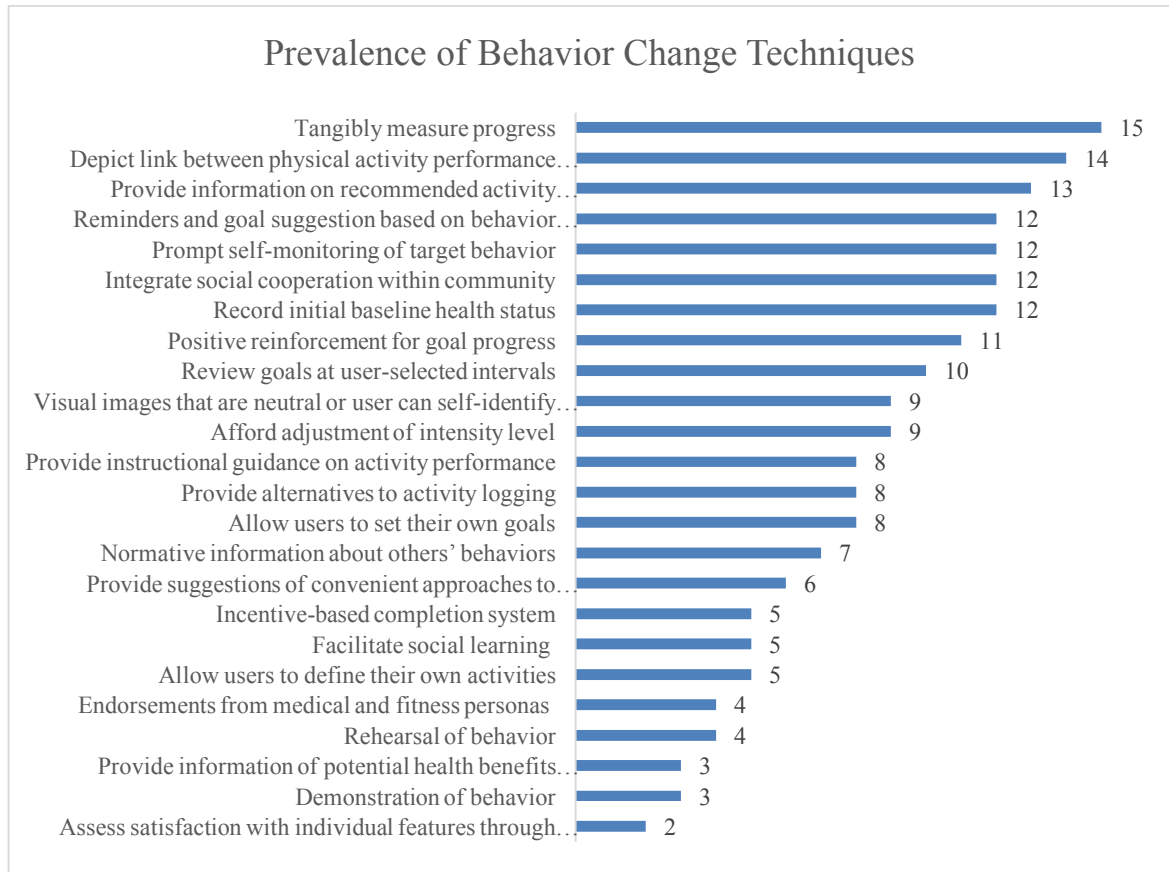
### **Prevalence of Behavior Change Techniques**

The final 16 apps were reviewed by three researchers from the Human Factors and Aging Laboratory and featured a mean average of 12.2 behavior change techniques (range 4-18) out of a possible 24. Apps like *StepFit* and *Pedometer* featured very basic tracking and performance display with no major reliance on a motivational strategy at all, thus featuring fewer behavior change techniques than other apps. While apps like *Pacer*, *MapMyFitness*, and *Pear* utilized more behavior change techniques, with similar implementations of goal and social support. The number of behavior change techniques found in each app reviewed can be seen in Table 11.

**Table 11. Number of applied behavior change techniques and the motivational strategies used in fitness apps**

<b>App</b>	<b>Behavior Change Technique Score (out of 24)</b>
Pacer – Pedometer Plus Weight Loss and BMI Tracker Coach	18
MapMyFitness	17
Pear- Personal Fitness Coach	17
Runner Square	16
Burn ‘em Down	16
RunKeeper	15
Up	13
Aaptiv	13
StepsApp	12
Endomondo	12
StepUp Pedometer	11
IDoMove	10
SitFit Exercise	8
Moves	7
Pedometer	6
StepFit	4

Researchers also looked across apps to discern the prevalence of behavior change techniques that were implemented. The most commonly seen behavior change techniques were *tangible measured progress* (n=15), *depicting link between physical activity and health outcome* (n=14), and *reminders and goal suggestions based on behavior history* (n=14), while *assess satisfaction with app features* (n=2) was found to be the least common behavior change technique. Figure 3 depicts the prevalence of each behavior change technique among the 16 apps reviewed.



**Figure 3. Prevalence of behavior change techniques in apps reviewed**

Assessing these selected apps based on a more inclusive set of behavior change techniques it was determined that on average, apps were found to feature less behavior change techniques than reported in previous studies (Cowan et al., 2012; Michie et al., 2009; Middelweerd et al., 2014). However, the most common behavior change techniques found in apps were found to be similar. This review was instrumental in identifying apps that were best suited to examine the effect of certain motivational behavior change strategies.



### App Selection for Comparative Analysis

Through a systematic analysis of each of the apps reviewed, I was able to identify the behavior change techniques and motivational design strategies that was primarily utilized by each app. Among the six motivational design strategies identified, previous research indicates that social influence and goal support have shown to be the most effective in improving physical activity behaviors in community-based, non-technological interventions. Thus, it is of particular interest to determine the effectiveness of these strategies as technological interventions. In order to evaluate the impact that social influence and goal support would have on older adults' physical activity levels, fitness apps were selected that implemented each of these strategies while also utilizing similar techniques in other categories of motivational design strategies (awareness, coaching, positive affect, and adaptation).

In order to select apps that would isolate these two strategies, I leveraged the content analysis performed on all 16 apps to identify those that featured a higher prevalence of social influence or goal support, with a seemingly similar representation of other strategies. Apps with similar representation among other design strategies were selected in order to detect an unbiased effect on physical activity levels (most apps featured tangible measured progress as a behavior change technique therefore it was harder to exclude this as an excluded technique). Apps were first reviewed for the presence of at least three, if not four of the behavior change techniques under social influence or goal support. This review narrowed the total app list from 16 to 10. Apps were then filtered by those that had a strong prevalence in both categories of social influence and goal support as it would be hard to

discern which strategy was causing any change in behavior. From the remaining 7 apps, additional apps were removed that only featured competition running as an activity option. The remaining 5 apps were compared side by side to determine which were most similar among other categories of motivational design strategies. From this content analysis, three apps were chosen for the second study of this dissertation; one app to represent social influence, one app to represent goal support, and a control app which does not heavily rely on any motivational design strategy but shows activity. Table 12 details the behavior change techniques that are featured in each of the selected apps.

**Table 12. Behavior change techniques in apps selected for Study 2**

<b>Selected App</b>	<b>Behavior Change Techniques</b>
StepFit (control ‘tracking’ app)	<ul style="list-style-type: none"><li>• Provide information on recommended activity</li><li>• Positive reinforcement for goal progress</li><li>• Incentive-based completion system</li><li>• Tangibly measured progression</li></ul>
Endomondo (‘tracking+social’ app)	<ul style="list-style-type: none"><li>• Depict link between physical activity performance and expected health outcome</li><li>• Provide information on recommended activity performance</li><li>• Facilitate social learning</li><li>• Integrate social cooperation within community</li><li>• Normative information about others’ behaviors</li><li>• Positive reinforcement for goal progress</li><li>• Tangibly measured progression</li><li>• Prompt self-monitoring of target behavior</li><li>• Afford adjustment of intensity level</li><li>• Provide alternatives to activity logging</li><li>• Allow users to set their own goals</li><li>• Allow users to define their own activities</li></ul>
Burn ‘em Down (‘tracking+goal’ app)	<ul style="list-style-type: none"><li>• Depict link between physical activity performance and expected health outcome</li><li>• Record initial baseline health status</li><li>• Provide information on recommended activity performance</li><li>• Integrate social cooperation within community</li><li>• Provide instructional guidance on activity performance</li><li>• Assess satisfaction with individual features through in-app ratings and feedback</li><li>• Positive reinforcement for goal progress</li><li>• Visual images that are neutral or user can self-identify with</li><li>• Tangibly measured progression</li><li>• Review goals at user-selected intervals</li><li>• Prompt self-monitoring of target behavior</li><li>• Reminders and goal suggestion based on behavior history</li><li>• Afford adjustment of intensity level</li><li>• Provide alternatives to activity logging</li><li>• Allow users to set their own goals</li><li>• Allow users to define their own activities</li></ul>

# **CHAPTER 7: EXAMINING THE EFFECTIVENESS OF MOTIVATIONAL DESIGN STRATEGIES IN MOBILE FITNESS APPS AMONG OLDER ADULTS (STUDY 2)**

## **Overview of Study**

There have been few comparative studies of mobile health and fitness apps intended to encourage and increase physical activity among underserved populations, specifically adults over the age of 65. By examining the effectiveness of motivational design strategies in a comparative study design, researchers and designers are able to understand what aspects of mobile health and fitness apps as physical activity interventions are truly successful in changing behaviors and which strategies are indeed relevant to the behaviors of older adults. Additionally, examining the effectiveness of each motivational design strategy serves to support the validity of each strategy as an effective and relevant approach to designing mobile health technologies for older adults.

The purpose of this study was to examine the effectiveness of existing mobile fitness apps to promote physical activity among a sample of older adults, based on the prominent behavior change strategies that they exhibit. Specifically, this study sought to examine the ability of each app to encourage an increase and maintenance of physical activity levels over time, as well as the ability of each app to encourage sustained engagement with the app itself. Three fitness apps (StepFit, Burn'em Down, Endomondo) were selected and deployed to focus on a distinct motivational design strategy and the effectiveness of that strategy in improving outcome measures from baseline performance. 39 older adult

participants were recruited to interact with one mobile app over a 10-week period. Physical activity and qualitative data measures were collected at the start of the 10-week period as a baseline assessment with follow-up assessments and a final assessment examining post measures following deployment of the fitness app.

This study addresses RQ3 and RQ4 by examining the effectiveness of health and fitness apps that leverage the social influence and goal support motivational strategies, and identifying the most desired features of health and fitness apps from the older adult perspective. Findings from this study will inform design criteria and guidelines for designing effective health-related behavior change apps for older adults. The overall goal of this study was to develop evidence-based design criteria for mobile health and fitness apps that encourage long-term use based on an understanding of motivational design strategy effectiveness, preferences and opinions of certain features that are deemed effective, and an overall assessment of older adults' experiences of interacting with mobile fitness apps.

### **Study Design**

A three-group, pre- and post-test, semi-longitudinal study was used to examine trajectory of use and effectiveness of each of the experimental conditions. Using a computer random numbers generator, each participant was randomly assigned to one of the three study conditions (13 participants per group) that they would interact with for the duration of the study. Participants were assigned to only one condition for a duration of 10 weeks, with 3 follow-up assessments during the 10-week period. Participant' attitudes,

mobile fitness app usage, and physical activity behaviors were collected both pre- and post-intervention and during follow-up assessments.

### **Recruitment and Screening**

Older adults were recruited through posted flyers and word of mouth as well as from the Human Factors and Aging Lab Participant Registry. Inclusion criteria included age (65-80 years), ownership and familiarity with a smartphone, and not currently using a mobile fitness app nor had they used a fitness app in the last year. During recruitment calls, interested participants were screened for their eligibility and then sent an initial Health and Demographics Questionnaire (Czaja et al., 2006) to complete prior to the baseline assessment. Participants were then scheduled for an in-person baseline assessment.

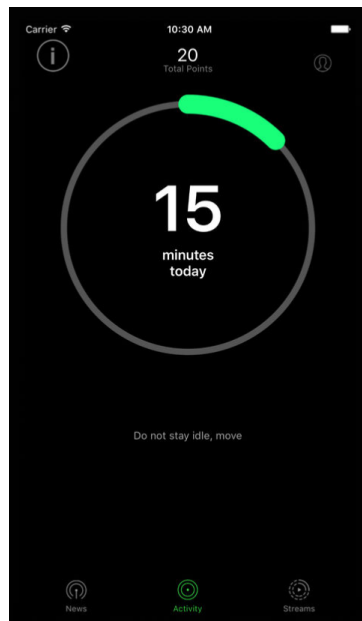
A total of 53 individuals expressed interest in participating in this study. Following screening during the initial recruitment call, 41 individuals were deemed eligible. Due to schedule constraints, 2 individuals dropped out of participating in the study and 39 were enrolled and scheduled for the initial baseline assessment.

### **Protocol**

#### Description of Interventions

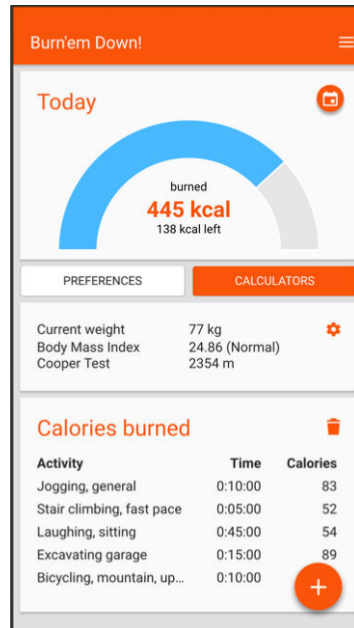
Participants were randomized to one of three intervention groups based on the content analysis of existing mobile fitness apps. Three off-the-shelf mobile fitness apps were selected to test the effectiveness of different motivational strategies: ‘*tracking*’ - an app that only tracked physical activity, showing only analytic data of minutes active (StepFit); ‘*tracking+goal*’ - an app that tracked physical activity and emphasized goal

support (Burn'emDown); and '*tracking+social*' app - an app that tracked physical activity and emphasized social influence (Endomondo).



**Figure 4. Screenshot of StepFit app**

Participants randomized to the basic analytic group were given the '*tracking*' app (Figure 4). This app tracks a user's physical activity by minutes active and reports points earned for the number of minutes active each day. Users are able to view the amount of points earned by week and a report of whether they met a minimum 30 minutes of activity every day on their personal profile. This app served as a control as there was no motivational strategy emphasized in this app.

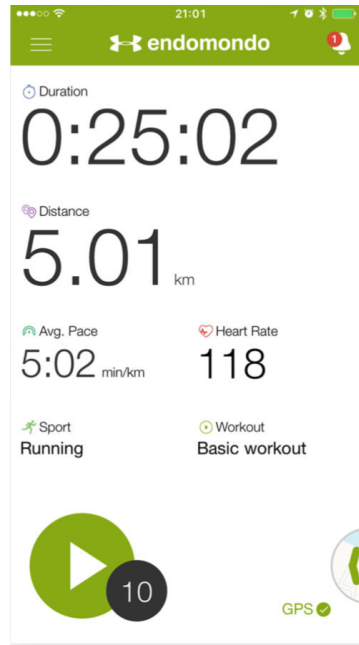


**Figure 5. Screenshot of Burn'em Down app**

Participants randomized to the goal support group were given the ‘*tracking+goal*’ app (Figure 5) to download and install on their phones. Upon first login participants set a calorie or performance goal and given a recommended metric to meet on a weekly basis. This app also outputs time active and calories burned, and allows the user to track activity in the moment or retroactively. This app also features several physical activity choices that range in intensity.

The ‘*tracking+social*’ app (Figure 6) was selected to test the effect of social influence as a motivational strategy. This app connects users to contacts and social media friends through an activity feed, challenges, as well as messaging and feedback on a user’s performance. Users are able to record a workout or activity, either at its initiation or after completed, and receive output of the distance tracked, minutes active, and calories burned. This app features several physical activity choices that range in intensity.





**Figure 6. Screenshot of Endomondo app**

### Measures

Pre- and post- measures were collected to compare attitudes and performance before and after interaction with a mobile fitness app and to evaluate the effect on behavior change. The following measures were collected at baseline assessment as well as the final assessment.

#### *Pre-intervention measures*

At baseline, participants each participant was assessed on their attitudes towards mobile health and fitness apps, current levels and frequency of physical activity, physical activity self-efficacy, mobile device proficiency, and their experience with mobile health and fitness apps.

### *Post-intervention measures*

Following the deployment period, participants completed questionnaires measuring their attitudes towards mobile health and fitness apps, levels and frequency of physical activity, evaluation of the usability of their assigned app, physical activity self-efficacy, and level of app use in minutes per week.

### Instruments

The following instruments were used to assess measures and outcomes from baseline to final assessment (See Appendices for instruments).

1. Background and Health Demographics Information Questionnaire

Basic demographic information was collected via a 29-item Health and Demographics Questionnaire. This questionnaire collected age, gender, education level, and marital status as integer values. Four questions assessed health status with an additional 10-item assessment of activity limitations. Prevalence of health condition was assessed by 17 additional items.

2. International Physical Activity Questionnaire

Levels (frequency and duration) of physical activity were assessed at both baseline and final assessment using the International Physical Activity Questionnaire (Booth, 2000) through self-report of physical activity intensity levels by hours and minutes, as well as the duration and frequency of sedentary activity in hours and minutes.

3. Self-Efficacy for Daily Physical Activity Questionnaire

Physical activity self-efficacy was collected via the Self-Efficacy for Daily Physical Activity Questionnaire (McAuley, 1993; McAuley & Mihalko, 1998). This

questionnaire consisted of nine variables which asked participants their level of confidence (0=not at all confident, 100=very confident) in performing three levels of physical activity intensity (light, moderate, and vigorous) for various periods of time.

4. Mobile Device Proficiency Questionnaire

Proficiency with mobile devices was assessed by the Mobile Device Proficiency Questionnaire (Roque & Boot, 2016) which evaluated the ease of performing 46 tasks on mobile devices in categories of *mobile device basics, communication, data and file storage, internet, calendar, entertainment, privacy, and troubleshooting and software management* using a 5-point scale (1- never tried to complete and 5- very easy to complete).

5. Mobile Fitness App Experience Questionnaire

A questionnaire was developed and used to assess experience with mobile fitness apps pre- and post-intervention. This questionnaire was adapted from the Health App Use among Smartphone Users questionnaire, developed by Peng et al. (2016) which collected participant history with downloading and using mobile fitness apps, and the reasons behind initial download and early abandonment if applicable.

6. Perceptions of Mobile Fitness Apps Questionnaire

Attitudes towards mobile fitness apps was assessed using a questionnaire that was developed to collect participant ratings of the usefulness, ease-of-use, and intention to use associated with mobile fitness apps based on a 7-point scale with 1- strongly disagree and 7- strongly agree. This perceptions questionnaire was adapted from the Perceived Ease of Use and Perceived Usefulness scales used in the TAM

(Davis, 1989) and consisted of 19 items. This measure was collected pre- and post-intervention.

7. App Download Instructions and Feature Overview

For each of the fitness apps deployed, an instructions manual was developed to give the user detailed instructions on finding and downloading the app, getting started with the app, and key features of the app.

8. Mobile Fitness App Use Questionnaire

A questionnaire was developed and used to collect each participant's self-reported use and interactions with their assigned mobile fitness app. Additionally, this questionnaire collected reasons for early abandonment or continued use of the app, intent to continue to use, and any social interactions during the use of the app.

9. UDMIG Questionnaire

The Universal Design Mobile Interface Questionnaire developed by Ruzic et al., 2016 was used to evaluate each fitness app based on 17 guidelines related to the ease-of-use and accessibility of the app. Items on this questionnaire related to interface contrast, alternate methods of input and output, error prevention, and screen legibility.

10. Motivations to Engage with a Mobile Health and Fitness App Questionnaire

Data was collected to assess the importance of various behavior change techniques as motivational components of health and fitness app. This 24-item assessment prompted participants to rank on a 5-point scale (1- 'not at all important' and 5- 'extremely important') how important each feature is for them to engage with a health and fitness app.

11. Online Survey Questionnaire

An online survey was sent to each participant via email at weeks 2, 5, and 8 as a checkpoint follow-up assessment. This questionnaire collected a self-report of physical activity levels over the last 7 days, frequency of app use (self-report), reasons for use or nonuse, and perceived effectiveness of the app.

Table 13 details the measures collected by each instrument.

**Table 13. Measures and instruments**

<b>Measure</b>	<b>Instrument(s)</b>	<b>Pre/Post</b>
Physical activity levels (self-report)	International Physical Activity Questionnaire Online Survey Questionnaires	Pre-, post-
Self-efficacy	Self-Efficacy for Daily Physical Activity Questionnaire	Pre-, post-
Attitudes towards mobile fitness apps	Perceptions of Mobile Fitness Apps Questionnaire	Pre-, post-
App use or nonuse (self-report)	Mobile Fitness App Use Questionnaire Online Survey Questionnaires	Post
Usability, satisfaction, and intent to use mobile fitness app	UD MIG Questionnaire Perceptions of Mobile Fitness App Questionnaire Online Survey Questionnaires	Post
Desired features of mobile fitness apps	Motivations to Engage with a Mobile Health and Fitness App Questionnaire	Post

### Procedure

Georgia Tech's Institutional Review Board approved this study. Upon receiving IRB approval, participant recruitment and screening began. Each participant was screened for their eligibility for this study and then scheduled for a baseline assessment. At the beginning of the baseline assessment, written informed consent was obtained from each participant before data collection began.

During the baseline assessment participants completed five questionnaires: The International Physical Activity Questionnaire, the Mobile Device Proficiency

Questionnaire, the Mobile Fitness App Experience Questionnaire, the Perceptions of Mobile Fitness Apps Questionnaire, and the Self-Efficacy Scale measure. Participants were then introduced to one of three mobile fitness apps that were pre-assigned by randomization. Key features and functionality of each app was reviewed with each participant and they were provided with a user guide to take home and consult when necessary (see Appendix I for sample download instructions and overview guide). Participants were instructed to use the app at the duration and frequency which suited their normal physical activity behaviors.

Participant self-report of app usage and physical activity levels were collected at weeks 2, 5, and 8 after the initial baseline assessment. Participants received an on-line survey at each of these follow-up checkpoints to inquire about their levels of physical activity in minutes per day, as well as their frequency and duration of app usage (minutes per day) and reasons for use or non-use of the app. In online surveys, participants were prompted to report their weekly levels of physical activity and app use as recorded by the app they were assigned, or to indicate those levels from memory if the app had not been used.

The final assessment consisted of six questionnaires and a group interview and co-design session. Participants were assigned to a group of being considered either a user (actively using the mobile fitness app assigned at the time of the follow-up) or nonuser (having not reported using the mobile fitness app on the last two follow-up assessments). At the beginning of the final assessment, participants were given a review of the purpose and procedure of the assessment. Participants then completed five questionnaires:

International Physical Activity Questionnaire, the Self-Efficacy for Daily Physical Activity Questionnaire, the Mobile Fitness App Use Questionnaire, the Mobile Fitness App Perceptions Questionnaire, and the UD Mobile Interface Guidelines Questionnaire. Each of the questionnaires were then reviewed and checked for completeness. Upon completion of the questionnaires, participants were guided through a group discussion about their experience following a discussion guide (Appendix M). Participants were asked about their overall likes and dislikes related to the mobile fitness app they used, perceived benefits of health and fitness apps, which features were considered motivating, and desired features and functionality of a successful mobile fitness app. Following the interview questions, participants were lead through a group co-design exercise where they brainstormed ideal and desired features for a health and fitness app. Prompts were provided to the group to brainstorm features that would encourage physical activity and features that would encourage continued use of the app. Participants were asked to go into as much detail as possible, and encouraged to visually sketch out any ideas they had. Following the co-design activity, participants completed the Motivations to Engage with a Mobile Health and Fitness App Questionnaire. Each participant was then provided with a debrief of the overall study, provided compensation and the final assessment concluded.

### **Data Analysis**

A multi-method approach was used with both pre- and post-quantitative (PEOU, PU, PSE, Self-Efficacy, Physical activity levels), and qualitative (interview and group design) analysis. Descriptive statistics of the participant sample were obtained from the Background and Health Demographics form and the Mobile Device Proficiency

Questionnaire. An initial analysis was performed on the baseline data from the overall sample and each of the experimental and control groups to assess any significant difference among groups in their median age, education level, mobile device proficiency, familiarity with mobile fitness apps, and physical activity self-efficacy. To assess the effectiveness of each app in improving physical activity levels from baseline assessment, pre-post paired comparison t-tests were performed on each individual's total hours of physical activity, as well as the total mean average as reported by the International Physical Activity Questionnaire. To evaluate any between-group differences across apps, an analysis of covariance was conducted. To examine the difference between app use (in minutes) between groups and across checkpoints, paired sample t-tests were used. Regression analysis was conducted on each measure collected to assess the correlation between variables to identify patterns.

Transcripts from group design sessions were transcribed verbatim by hand. Deductive thematic analysis was used for the analysis of the qualitative data and patterns were observed among themes for all groups and then user groups versus nonuser groups.

## **Results**

### **Participant Descriptive Information**

The initial sample consisted of 39 older adults age 65 to 80 ( $M= 71.7$ ,  $SD=3.93$ ) with 13 participants in each group. The initial participant sample was 72% female ( $n=28$ ), 64% were educated with a bachelor's degree or higher, 36% were married and 64% were either single, widowed or divorced, 46% Caucasian and 49% black. Participants rated their

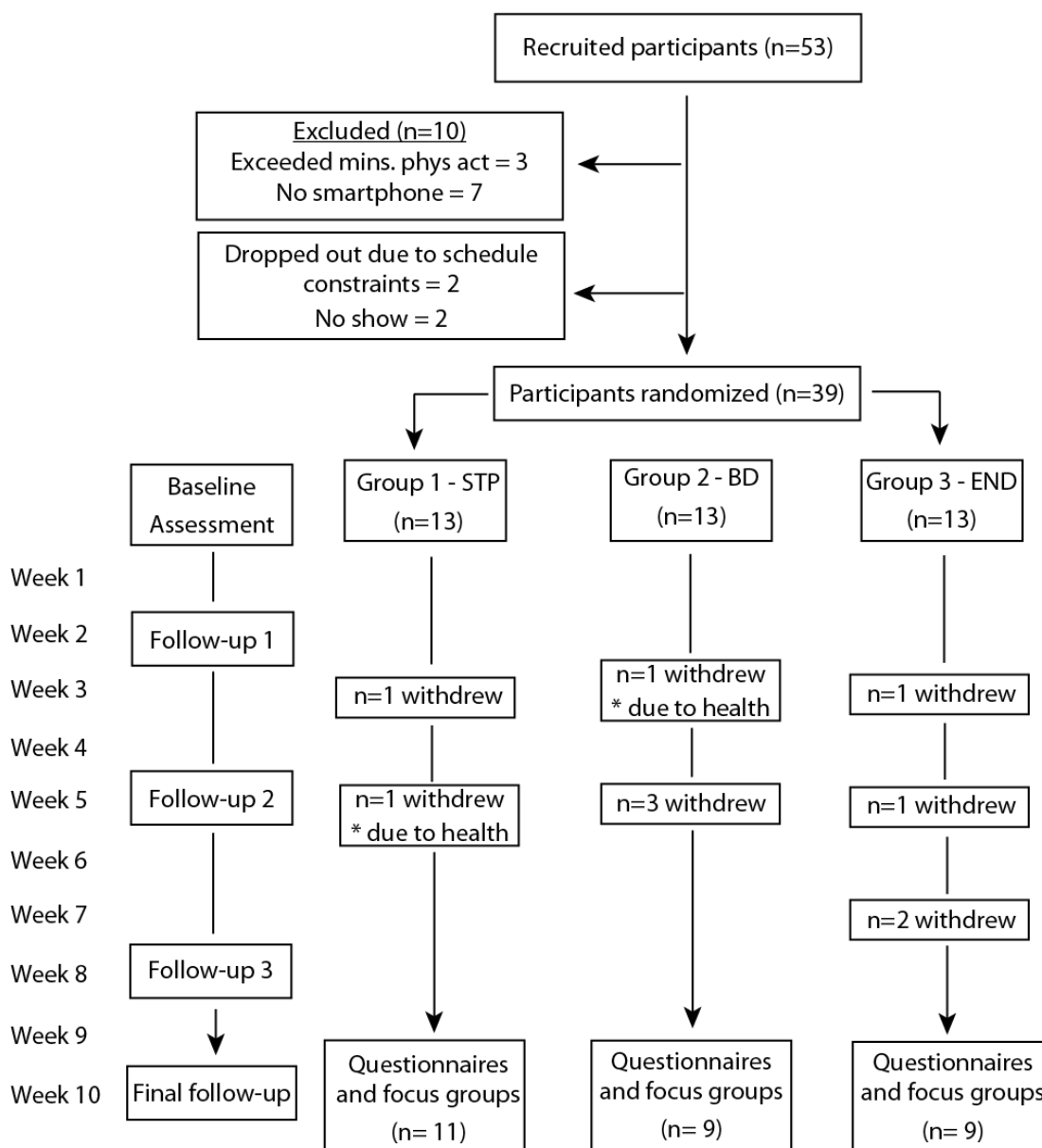


general health as “good” to “very good” on a scale of 1=poor, 3=good, and 5=excellent ( $M=3.7$ ,  $SD=0.78$ ). There was no statistical significant difference in demographics between groups at baseline. Table 14 describes the participant demographics of the total initial sample at baseline assessment.

**Table 14. Baseline participant descriptives**

<b>Descriptive</b>	<b>Group 1 – ‘tracking’ <i>n</i> (%)</b>	<b>Group 2 – ‘tracking+goal’ <i>n</i> (%)</b>	<b>Group 3 – ‘tracking+social’ <i>n</i> (%)</b>	<b>Overall Sample <i>N</i> (%)</b>
Gender (Female)	8 (61.5)	11 (84.6)	9 (69.2)	28 (71.8)
Age ( $M \pm SD$ ) [Range]	$73 \pm 4.5$ [65-79]	$71 \pm 4$ [67-80]	$70 \pm 3.2$ [65-76]	$71 \pm 3.9$ [65-80]
Phone Type				
iPhone	6 (46.2)	7 (54)	7 (54)	20 (51)
Samsung	1 (7.7)	4 (31)	3 (23)	8 (21)
LG	6 (46.2)	2 (15)	3 (23)	11 (28)
Prior Fitness App Use	2 (15)	4 (31)	4 (31)	10 (26)
Prior Use of Social Media	7 (54)	9 (69)	8 (62)	24 (62)
	$M \pm SD$	$M \pm SD$	$M \pm SD$	$M \pm SD$
Mean Mobile Device Proficiency (out of 40)	32.8	25.8	30.8	29.8
Baseline physical activity (min/wk)				
Total Activity	$165 \pm 83$	$172 \pm 113$	$206 \pm 96$	$201 \pm 87$
Walking/Light	$111 \pm 39$	$88.5 \pm 51$	$98.8 \pm 59$	$109 \pm 43$
Moderate	$19.6 \pm 48$	$62.3 \pm 71$	$48.5 \pm 51$	$50 \pm 63$
Vigorous	$33.9 \pm 56$	$21.5 \pm 38$	$59.2 \pm 64$	$41 \pm 55$

In total, 29 out of 39 participants (75%) provided follow-up data at the 10-week final follow-up assessment. A test for proportions showed there was no statistical difference in dropout rate between groups ( $z=1.96$ ,  $p=.636$ ). Figure 7 shows the flowchart of participant retention throughout the study.



**Figure 7. Participant retention flowchart**

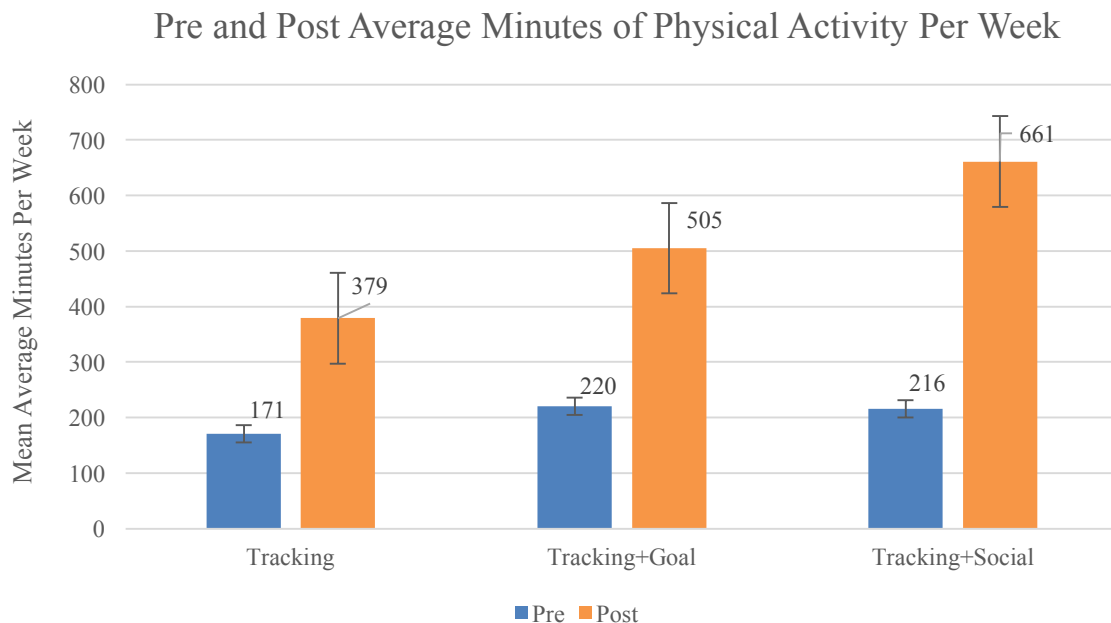
### Effect of App Use on Physical Activity Levels

Most participants of the overall sample (69%) reported an increase in their weekly physical activity levels from baseline performance (see Table 15). Change in physical activity level was calculated by assessing whether the sum of activity in minutes for each activity intensity was higher or lower than the sum of activity minutes reported at baseline.

**Table 15. Percent of sample that reported change in physical activity level by group**

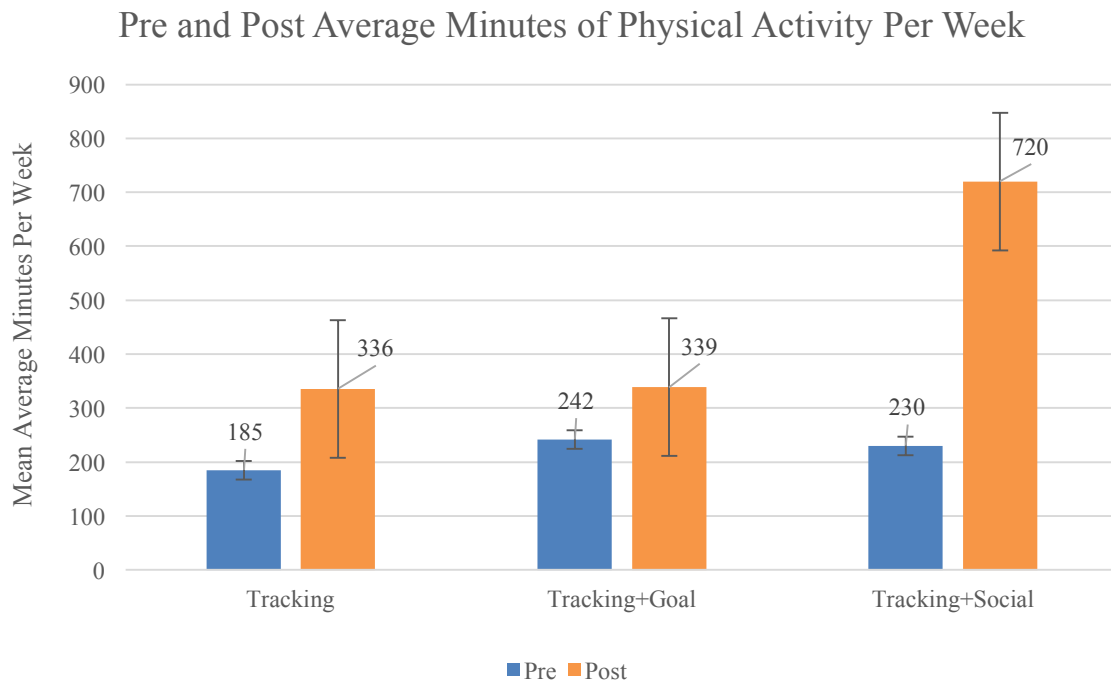
	tracking (n=11)	tracking +goal (n=9)	tracking +social (n=9)	Users (n=16)	NonUsers (n=13)	Overall (n=29)
<b>Total Activity</b>						
%increase	73%	67%	67%	56%	85%	69%
%decrease	23%	22%	33%	38%	15%	28%
%no change	0	11%	0%	6%	0	3%
<b>Walking/Light Intensity</b>						
%increase	64%	89%	44%	50%	85%	66%
%decrease	36%	11%	33%	50%	0	28%
%no change	0	0	22%	0	15%	7%
<b>Moderate Intensity</b>						
%increase	55%	44%	44%	38%	62%	48%
%decrease	9%	33%	33%	31%	15%	24%
%no change	36%	22%	22%	31%	23%	48%
<b>Vigorous Intensity</b>						
%increase	27%	44%	56%	50%	31%	41%
%decrease	18%	22%	44%	25%	31%	28%
%no change	55%	33%	0%	25%	38%	31%
<b>Days Active</b>						
%increase	27%	33%	33%	31%	31%	31%
%decrease	64%	22%	22%	50%	23%	38%
%no change	9%	44%	44%	19%	46%	31%

Overall, there was a statistically significant difference between the physical activity levels as reported by the mean average minutes per week at baseline and final follow-up. The primary question of interest for this study was whether either of the apps that featured motivational design strategies would increase older adults' physical activity from baseline and whether there was a difference in that effect between the goal-oriented and social-oriented apps compared to the app that did not feature a motivational design strategy. All three apps showed significantly higher levels of physical activity at the final assessment ( $F_{1,72}=6.72, p=.01$ ). Figure 8 shows the pre- and post- mean average minutes of physical activity by group.



**Figure 8. Pre- and post- mean average minutes of physical activity per week**

A paired t-test conducted on physical activity data for participants that continued to use the app throughout the full duration of the study ( $n=16$ ) revealed that there was no statistically significant difference in total activity between groups from baseline to final follow-up ( $F_{1,12}=4.3, p=.06$ ), due to such a small sample size. Despite a lack of statistical significance for this analysis, data trends showed a larger increase from baseline to final follow-up for the *tracking+social* group (Figure 9). One factor that may have attributed to this increase was the facilitation of social connection elicited by features in the *tracking+social* app, as the only participants that reported experiencing any social connection, whether facilitated by the app or not, were participants of the *tracking+social* group.



**Figure 9. Pre- and post- mean average minutes of physical activity per week of participants who continues to use app throughout 10 weeks**

### *Self-Efficacy*

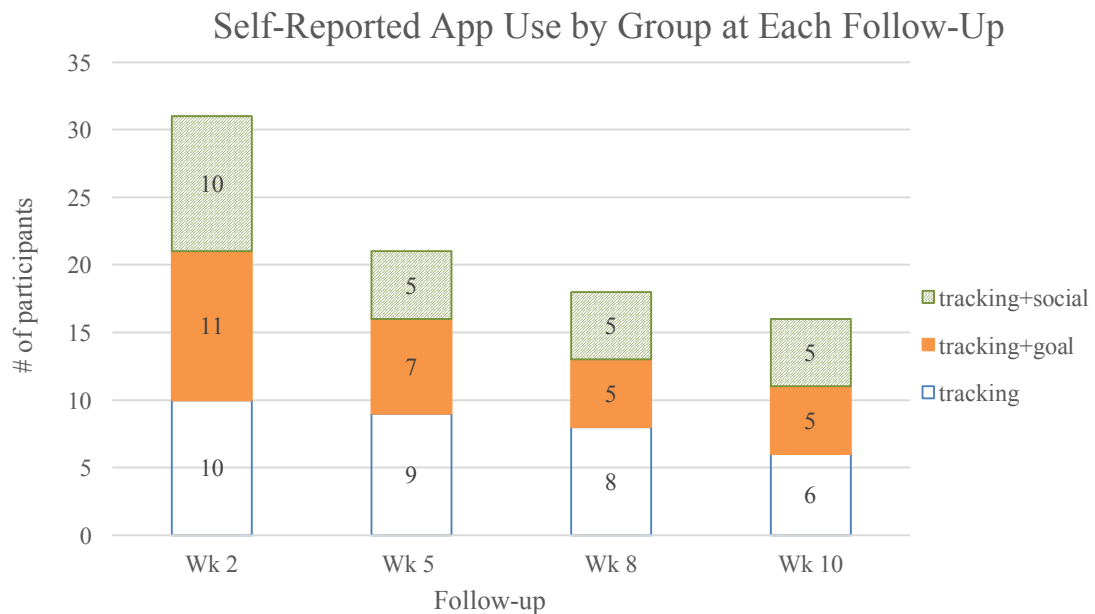
An ANOVA examining perceived self-efficacy to perform physical activity was conducted for the 30 minutes of physical activity category. This test revealed no main effect for condition and no significant interaction (see Table 16). The lack of change in perceived self-efficacy may have occurred due to a smaller sample size within each group and fairly high ratings of self-efficacy at baseline for light activity.

**Table 16. Mean perceived % self-efficacy to perform physical activity by group**

	tracking		tracking+goal		tracking+social	
Category of Activity	pre	post	pre	post	pre	post
30 minutes of light	84.5	84.5	96.7	91.1	87.8	80
30 minutes of moderate	60.9	70.9	72.2	77.8	64.4	60
30 minutes of vigorous	24.5	32.7	40	38.9	30	36.7

## App Usage Patterns

On average, participants used their assigned app for 6.3 weeks (44 days). At week 10, 55% of the final participants were still using their assigned app, and 28% of the final sample indicated an intention to continue to use their app after the conclusion of the study. Figure 10 shows the number of participants that reported still using their assigned app at each of the follow-ups.



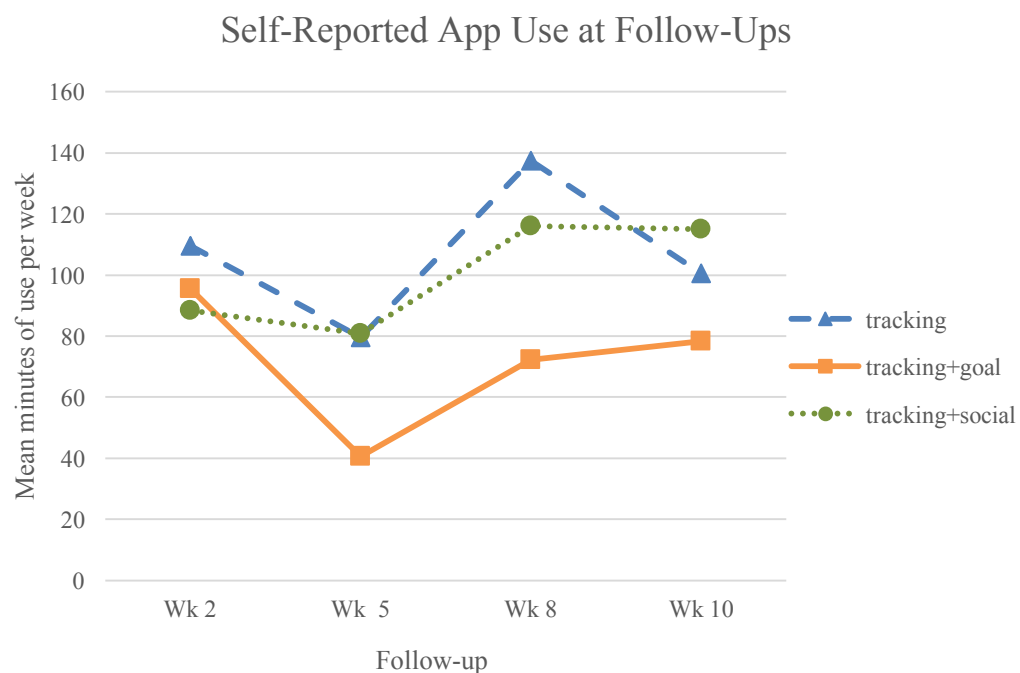
**Figure 10. Self-reported app use by group**

### *Frequency of Physical Activity Tracking*

Overall, all three groups followed the same trajectory of app use. The amount of app use per week declined between weeks 2 and 5, and increased between weeks 5 and 8 for all three groups. App use among the *tracking* and *tracking+social* groups saw an additional decline between week 8 and the final follow-up at week 10. On average, the overall sample used the app they were assigned for 90 minutes per week. There was a

higher mean frequency of use reported by participants in the *tracking* group at weeks 2 and week 8.

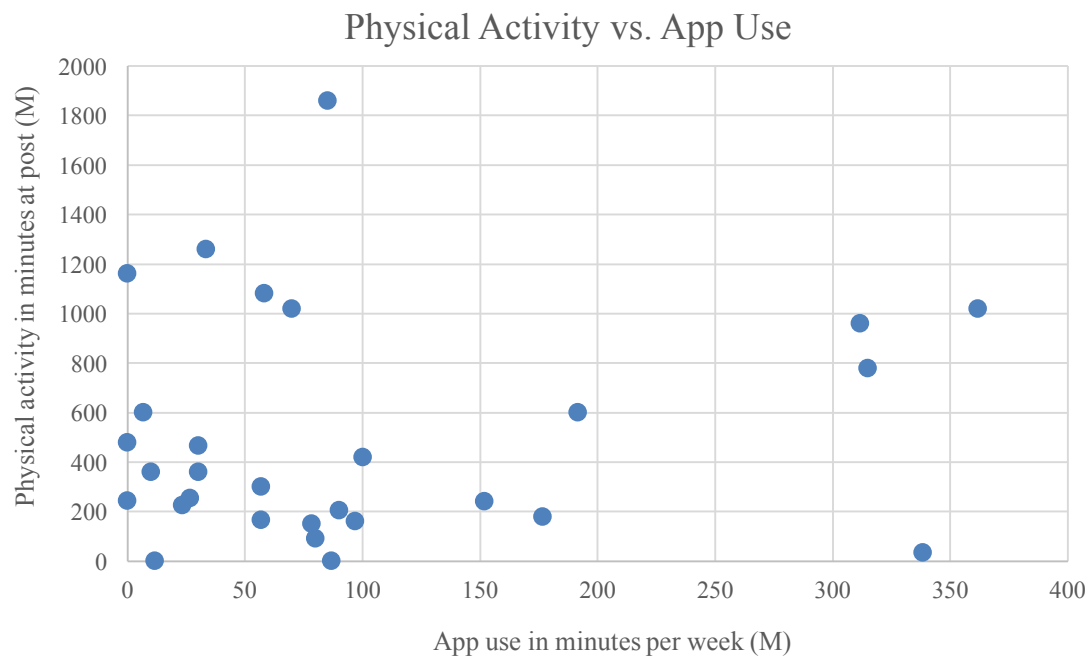
For participants in the *tracking+social* group, the mean app use in minutes was not significantly different between each follow-up. For the *tracking+goal* group, there was a statistically significant decrease between the app use at the first and second follow-up ( $p<.05$ ), with no significant difference between any other follow-ups. At week 8, there was a statistically significant difference between the *tracking* and *tracking+goal* group ( $p=.03$ ). There was no other significant difference between the groups at each follow-up. Figure 11 shows the reported app use by group in mean average minutes at each follow-up.



**Figure 11. Mean minutes of app use per week at each follow-up**

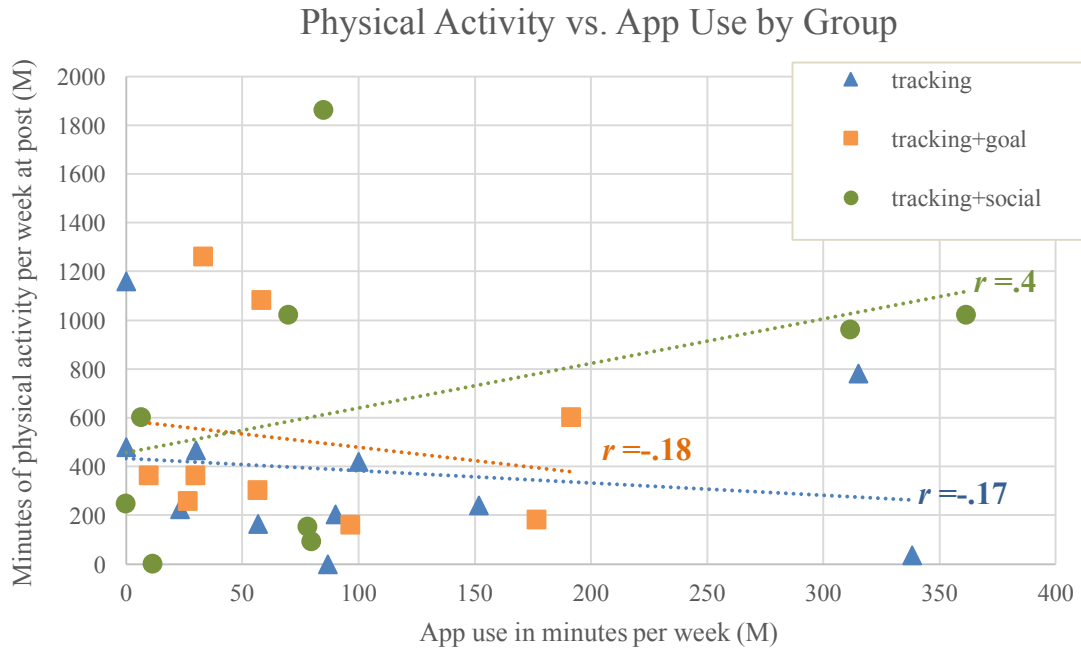
To discern whether the change in physical activity levels as reported by participants were a result of the app that was used, a correlation analysis was performed on participants' average minutes of physical activity against their average app use in minutes at final

follow-up. From the overall sample of participants that completed final baseline assessments, a small correlation of  $r=.11$  was found, suggesting that app use had a small effect on physical activity levels. Figure 12 displays a scatter plot of physical activity in minutes versus app use in minutes. This graph could potential be explained by many participants commenting that simply having the app made them more aware that they should be physically active, thus causing them to make an effort to perform more activity. This indicates that actually using the app for long durations of time may not have that much influence on the amount of activity performed.



**Figure 12. Correlation of physical activity and participant app use**





**Figure 13. Correlation of physical activity and participant app use by group**

When exploring the correlation between app use and physical activity level by group however, a larger correlation was found for the *tracking+social* group ( $r=.4$ ) than the *tracking+goal* group ( $r=-.18$ ) or the *tracking* group ( $r=-.17$ ) as seen in Figure 13. This suggests that there was more of an effect for the social influence app compared to the other two app groups.

Additional exploratory analysis indicated a small correlation between mobile device proficiency and participant app use ( $r=.37$ ), suggesting that older adults that are more proficient in using smartphones utilized fitness apps more frequently. Decreases in average use among groups may be explained by the attrition of overall use; participants that were no longer using the app but still enrolled in the study may have had a negative impact on the overall group mean. Initial decline may have also resulted from a perceived

ineffectiveness related to physical activity motivation. Additional factors contributing to app use or nonuse are discussed in the next section.

#### Factors of App Use and Non-Use

Factors of use and nonuse were collected at the final follow-up assessment. As previously mentioned, a little over half (55%) of the participants that provided data at final follow-up reported still using the app they were assigned for the study. Of those participants that were no longer using their app ( $n=13$ ), 46% reported discontinuing use due to not finding the app useful to their overall fitness goals, and 54% reported discontinuing use to usability issues with the app and the app being difficult to use. Participants who reported that their assigned app did not meet their overall fitness goals emphasized three major factors: the app doesn't provide useful reminders, the app is not enjoyable, and the app does not track non-exercise activities. Table 17 shows the breakdown of factors related to use and nonuse of the fitness app assigned to each group, for this breakdown total number of reasons listed was summed and then a frequency analysis showed the prevalence of each reason among all reasons mentioned.

**Table 17. Reasons for app use and nonuse**

	<i>tracking</i> group	<i>tracking+ goal</i> group	<i>tracking + social</i> group	overall sample
<b>Reasons for Use</b>	<i>n</i> =5	<i>n</i> =5	<i>n</i> =6	<i>n</i> =16
awareness of app motivates me to be more active	2	3	3	8
app is easy to use	1	0	0	1
app is useful to tracking overall health	1	0	2	3
app shows my progress towards my goal	0	2	0	2
app provides information on health benefits	1	0	0	1
app shows me how to be physically active	0	0	1	1
app connects me to others being physically active	0	0	0	0
<b>Reasons for NonUse</b>	<i>n</i> =6	<i>n</i> =4	<i>n</i> =3	<i>n</i> =13
I met my fitness goals/no longer need	0	1	0	1
app is difficult to use	2	2	2	6
app doesn't provide useful reminders	1	0	0	1
app is not enjoyable	1	0	1	2
app does not track non-exercise activities	1	0	0	1
app is not helpful in tracking my fitness	1	1	0	2

Qualitative data from final follow-up assessments also suggested that other factors of nonuse included the time and demand of having to input data and the lack of activity tracking for non-traditional physical activities. During group interviews participants expressed that these apps required too much effort to identify the activity being completed at the time as well as the start and stop times of the activity.

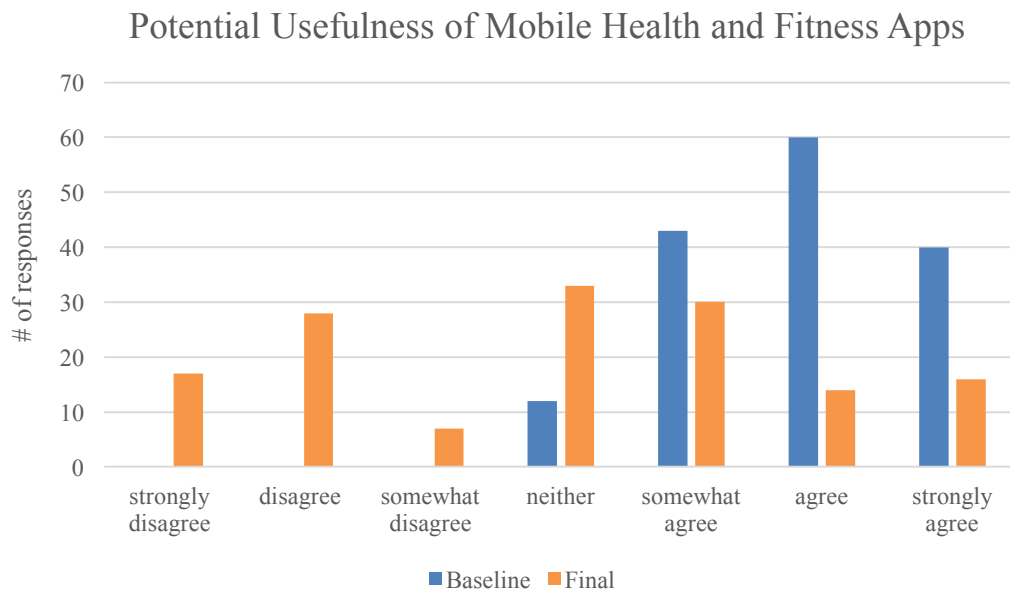
### Perceptions of Mobile Fitness Apps

#### *Perceived Usefulness*

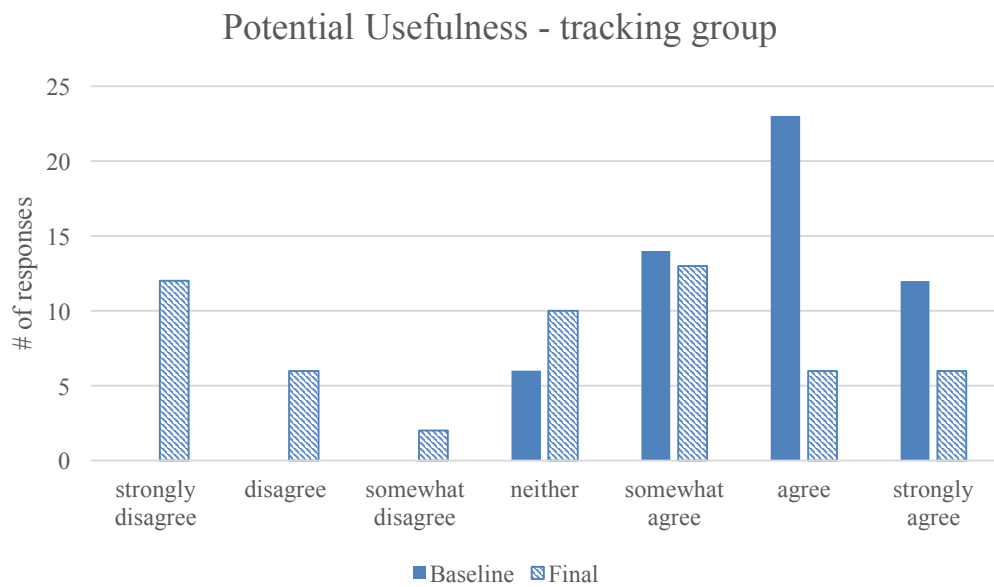
On average the overall sample of participants rated the use of mobile health and fitness apps moderately effective in helping them with their fitness goals ( $M=3.2$ ,  $SD=1.3$ ) on a 5-point scale where 1=extremely effective, 2=very effective, 3=moderately effective,

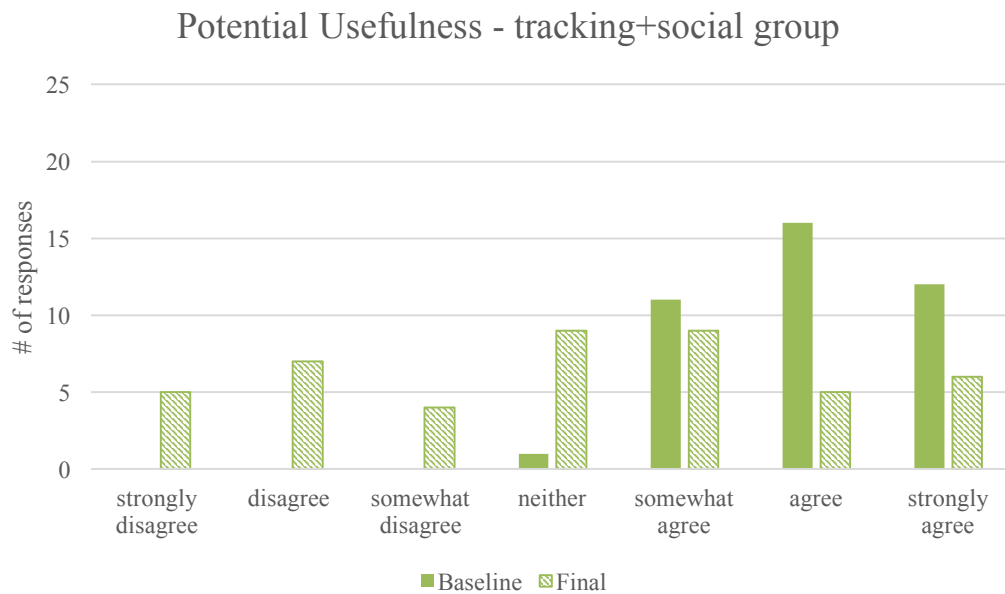
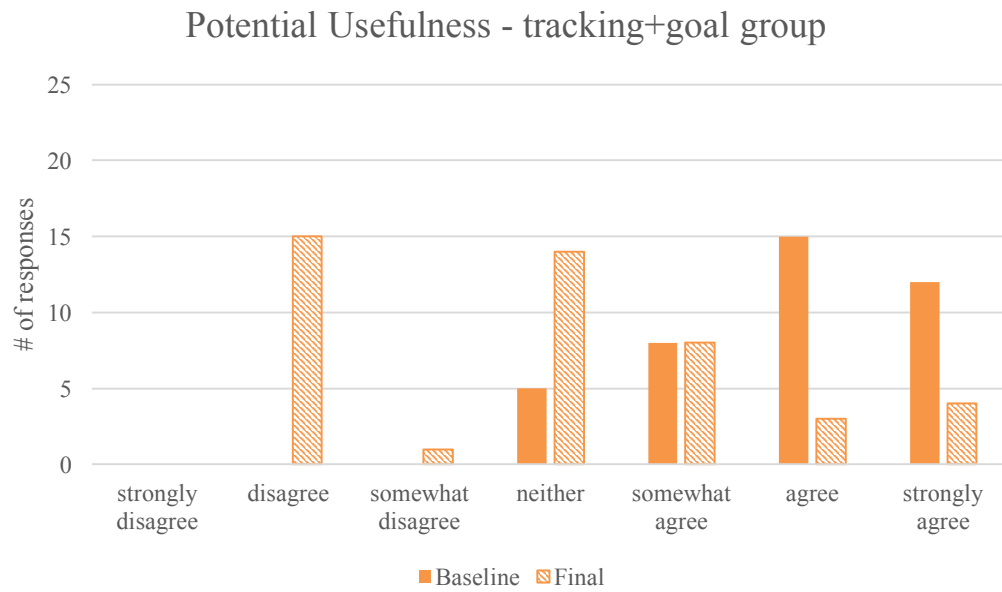
4=slightly effective, and 5=not at all effective. Among participants who felt that their app was effective ( $n=14$ ), effectiveness was attributed to two main behavior change techniques: being able to see if individual goals were met, and displaying of health information and tips. Other motivational techniques that contributed to effectiveness were identified as having a variety of activities to choose from, and timely feedback. Only one user out of the sample identified being connected to other people using the app as motivational although they were not in the social influence (*tracking+social*) group.

Additionally, when participants were asked if using a mobile health and fitness app would benefit them at their age, a majority of participants responded positively (somewhat agree to strongly agree;  $n=21$ ); See Figure 14. Despite ratings of moderate effectiveness, there was a negative shift in the perceived usefulness of mobile health and fitness apps from baseline to final follow-up assessment. This shift appeared consistently across groups (see subsequent figures in Figure 15), although there was more of an equal distribution at final assessment for the *tracking+social* group.



**Figure 14. Overall sample responses to the perceived usefulness questions**





**Figure 15. Responses to the perceived usefulness questions by group**

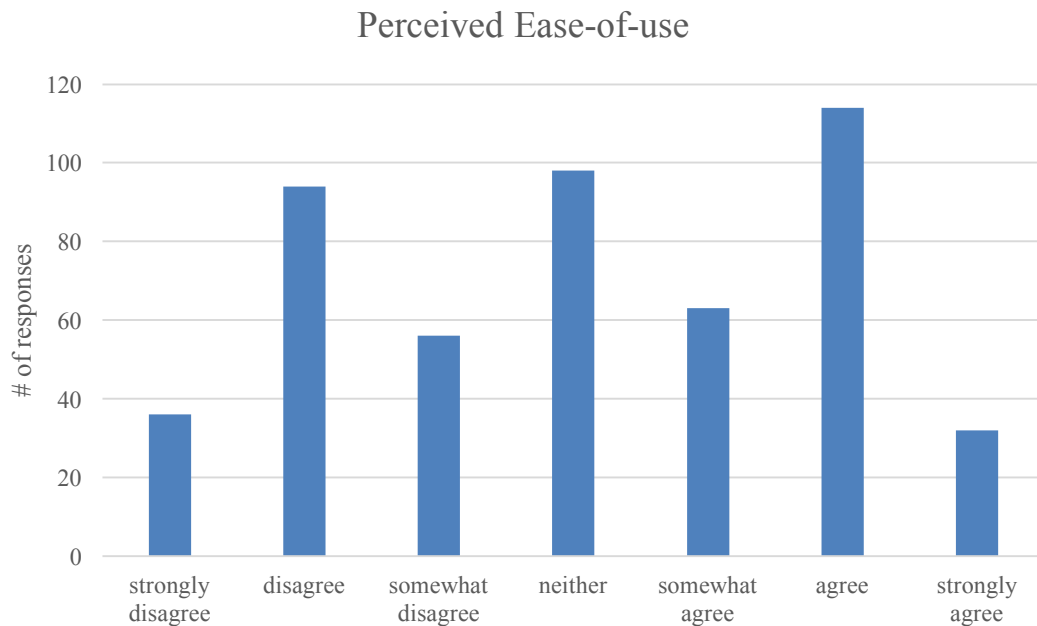
The question of whether participants felt that mobile health and fitness apps would be beneficial to them at their age also saw a negative shift in responses. Overall participants rated their agreement with this question at baseline as agree ( $M=5.97$ ,  $SD=0.23$ ), and at

final follow-up this agreement was rated as somewhat agree ( $M=5.1$ ,  $SD=1.9$ ). While there was no significant difference between the mean ratings of the overall sample between pre- and post-measures, a paired t-test showed a significant difference in the mean average ratings for the *tracking+goal* group ( $p=.009$ ) with the mean rating dropping from 6.22 (agree) to 4.37 (neither agree or disagree).

Participants were asked to identify how well their assigned app motivated them to be physically active on a 5-point scale (extremely motivated, very motivated, somewhat motivated, not very motivated, not at all motivated). Out of the overall sample, 55% of participants felt that the use of the app they were assigned motivated them somewhat to be physically active. Questions regarding the usefulness of a participant's assigned app to their physical activity levels or overall health were rated neutral ( $M=4.07$ ,  $SD=.35$ ). When asked if participants felt that use of the fitness app was useful to their fitness needs, participants responded that they somewhat disagreed ( $M=3.3$ ,  $SD=1.7$ ). These ratings compared to baseline ratings indicate that the use of the three health and fitness apps deployed had a negative impact on participants' perceptions of these systems as physical activity interventions. Follow-up comments to these ratings included relevance of app functionality to exercise and physical activity, tracking activities that are considered high risk (i.e. boxing, scuba-diving, etc.) and not related to older adults' desired activities, and complex system workflow requiring users to have to manually enter the start and stop of activity each time they changed what they were doing.

### *Perceived Ease-of-Use and Usability Concerns*

Perceived ease-of-use is defined as the perceived effort required to operate a system. This perception was evaluated using the UD-MIG (Ruzic et al., 2016). Participants' responses during final follow-up varied with regard to the overall usability of the apps deployed with the modal response being that they agreed that the health and fitness app assigned was usable. Figure 16 shows the overall distribution of responses to system usability. Analysis of variance determined that there was no statistical significant difference in the mean ratings of system usability between groups ( $p=.64$ ).

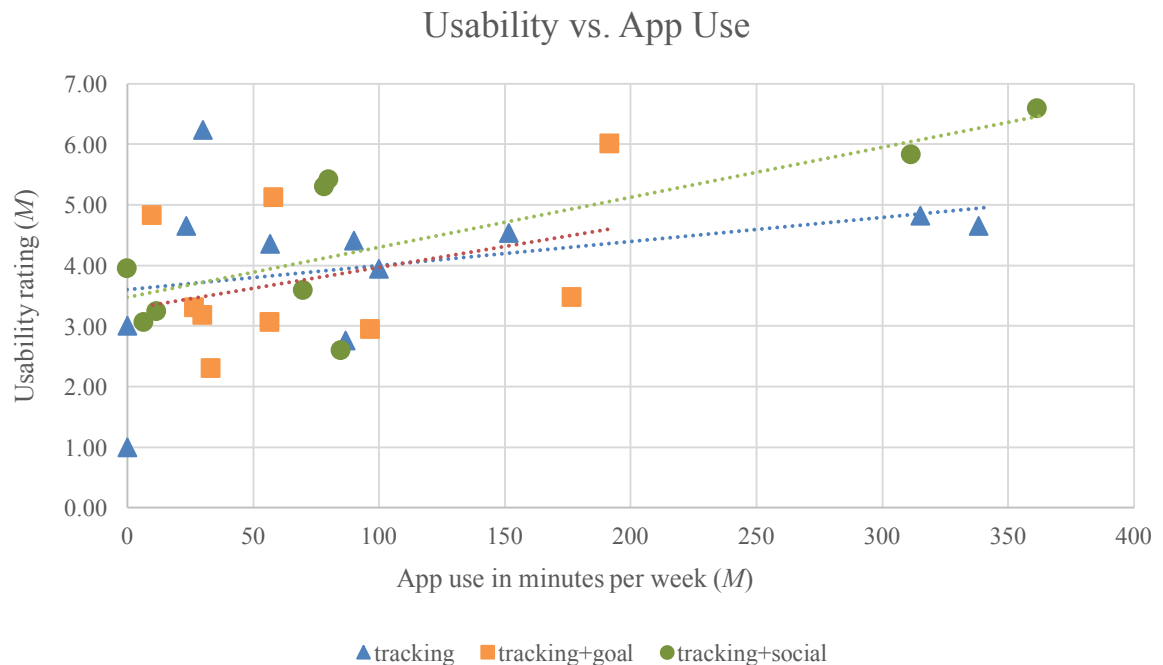


**Figure 16. Perceived ease-of-use among overall sample**

Questions related to visual accessibility as defined by users rated slightly lower with a mean rating of 3.5 ( $SD=0.7$ ) indicating that participants somewhat disagreed that these apps were visually accessible. Exploring the relationship between usability ratings and app use, higher usability ratings were correlated with higher app use, as seen by a large



effect of  $r=.52$  for the overall participant sample (See Figure 17). This correlation suggests that the more usable an app was considered, the longer a participant engaged with that app.



**Figure 17. Correlation of app usability to mean average minutes of app use per week**

### Perceptions of Behavior Change Techniques

Perceptions of the effectiveness of the six motivational design strategies were collected by participant ratings on a 7-point scale going from 1=strongly disagree to 7=strongly agree. Initial ratings of perceived effectiveness suggest that informing users of their progress was perceived to be the most relevant to maintaining physical activity levels ( $M=6.38$ ,  $SD=0.71$ ), as well as the most likely to be associated with sustained engagement with a mobile health and fitness app ( $M=6.38$ ,  $SD=0.63$ ). Social connection was rated the lowest as a motivation strategy for both physical activity motivation ( $M=4.08$ ,  $SD=1.67$ )

and encouragement to sustain use of a mobile health and fitness app ( $M=3.54$ ,  $SD=1.57$ ).

Table 18 shows the mean ratings for each strategy at baseline.

**Table 18. Mean average ratings of motivational design strategies at baseline**

Motivational Design Strategy	Perceived Effectiveness to Encourage Physical Activity Rating ( $M$ )	Perceived Effectiveness to Sustain Fitness App Engagement Rating ( $M$ )
Goal Support	6.38	6.38
Positive affect	6.05	6
Awareness	5.95	5.77
Adaptation	5.95	5.85
Coaching	5.72	5.56
Social Influence	4.08	3.54

During the final assessment, participants rated each of the behavior change techniques from most import (rating of 5) to least important (rating of 1) based on their experience with the assigned mobile fitness app (Table 19). Overall participants rated techniques like ‘*tangibly measures progress*’ and ‘*records initial baseline health status*’ as being most important. All four behavior change techniques associated with the social influence strategy were rated among the least important. These techniques also received lower ratings among participants in the *tracking+social* group. During the follow-up group interviews, participants indicated that social influence from a larger network of individuals they may not know would not be beneficial to physical activity and app use, but that connection to friends or family would be valuable: “I think connecting to strangers would be useless. You don't know them, you have no interest in what they do. I think it would be more beneficial to have it connect you, or allow you to choose people that you connect to that you know and have a little friendly competition”.

All three groups rated behavior change techniques associated with goal support higher than other techniques. These findings not only suggest that interaction with the mobile health and fitness app did not change the overall perception of effectiveness and importance of these techniques, but also suggests that social influence as defined was not relevant to older adults' physical activity behaviors or sustained engagement with the fitness app. Goal support as a motivational strategy and the behavior change techniques associated with this strategy were perceived to be more relevant: "Just establishing a goal and seeing if you met that goal is motivation enough for me at this age".

**Table 19. Highest ranked and lowest ranked behavior change techniques**

<b>Rank</b>	<b>Highest Ranked</b>	<b>Rating (<i>M</i>)</b>	<b>Lowest Ranked</b>	<b>Rating (<i>M</i>)</b>
1	Tangibly measures progress through steps, days, or other measures	4.10	Connects me to a community of people doing the same health-related behavior I'm doing	1.86
2	Records initial baseline health status	3.93	Informs me that other people are doing the behavior	1.90
3	Reviews my goals at times that I specify	3.76	Allows me to learn to do a health-related behavior from other people	2.14
4	Suggests new goals based on my progress and performance	3.72	Plans when and where I can perform the intended behavior	2.31
5	Positive reinforcement for goal progress	3.66	Endorsements from medical and fitness professionals	2.38

## Discussion

This study helped to identify the ways in which social influence and goal support can be effective as motivational design strategies when implemented in mobile fitness apps. Results from this study indicate that there were trends among the *tracking+social* group of higher levels of physical activity from baseline and a reported higher average app use when

compared to the *tracking+goal* group. Although each group showed positive trends of increases in reported physical activity levels, the *tracking+social* group was the only group that had a positive correlation between physical activity level and app use. This suggests that there may be other factors which contribute to a positive shift in physical activity behaviors, such as the general awareness felt by just having a health and fitness app on one's phone. These findings also indicate a need to further examine meaningful interactions with health and fitness app such being that longer interactions do not necessarily lead to more of a change in behavior.

Additionally, data trends found in this study suggest that we are able to quantify the impact of designing with socially-oriented motivational strategies on health-related behaviors. Participants often rated social influence lower in comparison to other behavior change techniques when assessing which features are ideal to increasing physical activity levels and sustaining engagement with a health and fitness app. In looking at these ratings and feedback regarding the usefulness of mobile health and fitness apps, we can deduce that there is indeed merit to social influence as a motivational design strategy but that its current implementation may need to be adjusted in order for it to be accepted as a frame for mobile health technologies.

Findings from this study paired with an in-depth understanding of ideal features and components of mobile health and fitness apps have the potential to inform successful health technologies.

## **CHAPTER 8: CO-DESIGN OF HEALTH & FITNESS APP FEATURES WITH OLDER ADULTS**

### **Overview**

In addition to examining the quantitative impact of each motivational strategy, Study 2 sought to establish an in-depth understanding of older adults' opinions of effective and preferred motivational strategies and app features. Literature suggests that there is value of older adults as co-creators of technologies as opposed to just consumers of the technology (Davidson & Jensen, 2013). Few studies have engaged older adults in participatory design activities for health technologies (Davidson & Jensen, 2013; Lee et al., 2016), or in the design of technologies and games more generally (Botero & Hyysalo, 2013; Lazar et al., 2016; Rice et al., 2012). These research efforts have resulted in identified design recommendations and tips for co-design as a methodology. While the method of participatory or co-design has been established, there is a unique value to engaging participants in this form of design and assessing co-ideated features for a desired technology with participants having exposure to the technology for which they are providing feedback.

To address RQ5 regarding identifying relevant features and components of health and fitness apps as expressed by older adults, co-design sessions were designed to engage study participants in a form of co-creation and ideation following their engagement with their assigned mobile fitness app. The overall goal of these sessions was to facilitate

conversation and design thinking among older adults, and gain a more in-depth insight into their needs and reasoning behind preferences of features.

### **Method**

Seven co-design sessions were conducted with participants as a part of the final follow-up assessment. Based on usage of their assigned apps, users were assigned to a nonuser co-design session ( $n=3$ ) or a user co-design session ( $n=4$ ). Participants that reported still using the fitness app assigned at baseline were grouped into user groups, those that reported no longer using the fitness app at week 8 were grouped into nonuser groups. Group assignments of user or nonuser were not dependent of the app that a participant was assigned at baseline assessment.

Following individual completion of survey questionnaires reported in Chapter 7, participants were guided through a semi-structured group interview about their experiences using a mobile fitness app. (See Appendix H for Interview Guide). Semi-structured group discussion questions covered the barriers and facilitators of interacting with a mobile fitness app, as well as discussion of the ideal features participants may want to see in a future app for health and activity promotion.

Participants were given four prompts and asked to individually brainstorm and ideate desired and ideal features of mobile health and fitness apps in response to those prompts. Participants were provided with ideation materials such as markers, drawing paper and sticky notes to aid in visualizing their ideas. The first prompt given asked participants to think about and sketch out features for a health and fitness app that would encourage them to be more physically active. The second prompt asked participants to think about and

ideate features of a health and fitness app that would encourage continued use of the app. The third prompt asked participants to think about and ideate features of health and fitness apps that they feel are unnecessary for them at their age. And the last prompt asked them to brainstorm things that are important for designers to consider when designing and developing health and fitness apps. For each prompt, participants were given individual time to brainstorm and ideate design features that they felt met the prompt given, and then groups discussed responses as a whole.

To analyze findings from these sessions, interview sessions were transcribed via hand and identification of themes were guided by session prompts as well as data-driven patterns from each transcript.

### **Desired Features of Health and Fitness Apps**

#### Activities and Metrics Tracked in Health and Fitness Apps

One of the main topics that emerged in the group interviews and co-design sessions were the types of activities and metrics that are currently tracked by health and fitness apps versus what would be valuable for older adults to know. Participants expressed a desire for more fluidity in the ways vigorous activities are defined among these apps, including more routine instrumental activities of daily living such as house and yardwork, or organizational and volunteer activities. While the apps used in this study tracked typical exercise activities (weight-lifting, bicycling, hiking, swimming) with walking being the primary physical activity included, participants expressed a desire to have their everyday activities such as

cleaning and yardwork (specifically mowing grass and gardening) and interacting with grandchildren tracked as physical activity.

In addition to the types of activities that are tracked and counted towards physical activity, participants suggested other areas of health that could be tracked with a fitness app. Both users and nonusers of health and fitness apps felt that integrating the tracking of health-related data that could feed in their medical records would be beneficial at their age. Specifically, sleep, hydration, and blood pressure were mentioned across all seven groups as something that would entice older adults to use health and fitness apps more frequently. Although participants found benefit in knowing their physical activity behaviors, they expressed that an app would be more valuable if it helped to track things they could report back to their doctor as a holistic evaluation of health: “I would like an app that shows me what the state of my health is. Like where my blood pressure is, heart rate. To let me know how much [physical activity] I’ve done. Collectively show the impact and separate out the activities like ‘Oh overall this number or count says that I did well and my health is in a good state’. So that when I go to the doctor I can tell the doctor”.

Tracking and assessing pain was also mentioned among the nonuser groups. Participants suggested that a helpful metric to track would be their perceived pain on any given day or moment: “I mean a start would be to just have something that once or twice a day you could go in and say that “my average pain today was a 7”. This metric was discussed as an additional way of keeping a record of overall health, and reported to be valuable when looking back to see how well physical activity helped with the perception of pain or pain management.



## Ideal Features

Basic tracking and awareness was seen to be encouraging to both physical activity and use of the app. Participants felt that using the apps made them more aware of their behavior and thus encouraged them to want to continue that behavior: “Just making you aware, is one of the best benefits. Making you think. I’m one who’s always taken the stairs, never taken an elevator, type thing. But it does make you more aware of other things”. In addition to tracking of an individual’s activity, participants also expressed that tracking of one’s goals were seen as an important feature to have in a health and fitness app. Discussion of this topic among groups supported quantitative ratings of goal support as a motivational strategy and the behavior change techniques that were associated with it.

Positive reinforcement and acknowledgement was identified as an ideal feature among both users and nonusers. Specifically, participants suggested tangible rewards such as gift cards or discounted gym memberships for positive physical activity progress. While virtual rewards may be visually appealing, having something tangible to show progress was expressed as something that would encourage older adults to stay engaged with the app. Participants also discussed how at their age the cost of fitness centers and gym memberships was seen as an unnecessary expense. Providing gift cards to locations frequently visited by older adults, or to activities associated with physical fitness classes would be considered a win-win for older adult users.

Auditory feedback and instructions were also commonly mentioned as an ideal feature to have in a health and fitness app across both user and nonuser groups. Participants discussed the use of voice feedback as a form of reminder to be active, or as a form of

encouragement to keep going or for doing a good job. In addition to feedback based on performance, voice service as an alarm or reminder was mentioned as an ideal feature to help encourage physical activity: “I’d want an alarm that I could set the day and the time that it could notify me like ‘hey it’s time to do your routine’”. In some groups, the use of auditory feedback was discussed as an accessibility feature that would alleviate the need to read small print on the screen to see the number of active minutes or steps performed in a day or week. Having a voice that provided feedback during physical activity was mentioned as a way to encourage an individual to continue progressing because they are near their goal.

Connection to others was reported as being an appealing feature when a user is being connected to people they know and are familiar with, though overall feelings about social connection through health and fitness apps were mixed among survey and questionnaire responses. Many participants saw the value in being connected in general and saw physical activity performance as a way to achieve this connection: “You need a connection. We as seniors we need connections. And one of the things that happens when we don’t connect, we become depressed. So it may be good to make sure that they have the same app. And they can call you up that morning and say, ‘Hey you wanna go walk or run or something?’”. Although several participants commented on the hesitation to want to connect to strangers, or to be urged to aggressively compete with people they don’t know, they found that social connection with those they are familiar with would make physical activity fun: “It’s good to have a partner for me. At least somebody that you would be accountable to, make it fun. ‘You know I did such and such today, what about you?’. See

if you can top that. They really enjoy each other and stay in contact. It's a good social outlet". As opposed to social competitions that may be intimidating, participants expressed a desire for social cooperation where they could workout with the encouragement of their friends or family that may live in other locations. Knowing the physical activity behaviors of strangers or even Facebook friends who may not be intimately close was discussed as a deterrence from using a mobile health and fitness app: "Yeah, [at] this point in my life, I don't do that. I don't want to be connected to strangers. We want to be disconnected. Just leave me alone. I think it's an older adult thing. You know, we're not big Twitters or Facebookers".

#### Age-Related Considerations

Although ease-of-use and accessibility were not direct questions or prompts during co-design sessions, this was consistently brought up in every group discussion as a main consideration for creating health technologies for older adults. Regardless of what useful features an app may or may not have, participants expressed that if it is too difficult to use they won't attempt to use it. Screen legibility and contrast were commonly discussed in this regard. Participants felt that often the text detailing feedback of their activity was hard to read from a comfortable distance, and suggested the use of larger numeric figures or icons that could easily be discerned. Voice controlled and auditory feedback was also mentioned here as something that would benefit the usability and accessibility of mobile apps. While the use of color and visual icons were things that were mentioned as appealing and attractive elements of health and fitness apps, participants felt that these should be standardized and more emphasis should be placed on the contrast and accessibility of these

colors. Many participants commented that they would prefer the use of simple greens for positive progress and red for negative or lacking progress.

Another main consideration mentioned consistently was the burden of carrying around one's phone to track activity. This was mentioned as something that was difficult to do during certain activities: "It's a little cumbersome, though, to have it [phone] on you and still try to do what you're trying to do. I mean it may vary by the type of phone, but I don't always have my phone on me so it wasn't always tracking". Thus, design efforts which focused on other forms of mobile health technologies would be advantageous to increasing activity and health management and tracking among older adults. Additionally, participants suggested a need for health and fitness apps as well as other technologies to be simpler to use and come with some form of tutorial or quick-start element that would help them get oriented with all of the in-system features.

### **Co-Design as a Method of Designing for Older Adults**

Co-design is an approach to product development where users are involved in the stages of ideation and early feedback, framing a more user-centered process. The primary purpose of this method was to allow older adults to ideate their own concepts of a mobile health and fitness app, and to facilitate discussion. One of the main values perceived during this process was the enthusiastic participation of individuals when they felt that their opinions were being heard and actualized. By utilizing this process, I was able to verify certain research and design directions, such as expanding the types of activities being tracked to be more inclusive and allowing users to connect with trusted friends and family

in their physical activity efforts. Engaging participants in the co-design approach allowed for real-time feedback and thus immediate refinement of future system features.

### Lessons Learned

This method may have benefitted greatly from participants having had exposure to the technology being discussed. Co-design is often conducted with some form of prototype or prompting artifact, however in this study participants had an extended period of time to interact with an assigned mobile health and fitness app. This interaction led to very informed perceptions and opinions of what aspects and features of health and fitness apps were useful and effective to older adults as users. Additionally, participants were able to readily identify the things they did not want in a health and fitness app, and brainstorm things that would be ideal with relevant context to the purpose and scope of health and fitness apps as a physical activity intervention. This format of feedback also encouraged feedback from all participants at will, and provided a level of detail that may have been otherwise difficult to achieve via questionnaire or survey.

Additionally, having participants rate the ideated features as a group allowed for clarification and agreement of the ideas and concepts that emerged from individual brainstorming. For example, one participant made mention that an ideal feature to encourage physical activity would be the tracking and reporting of water intake. Resulting conversation with other participants clarified that hydration is something that should be holistically considered along with other health metrics that communicated a person's entire health status, contributing to a user wanting to be more physically active because they know

their status. Additional comments mentioned that this would also increase the likelihood of older adults remaining engaged with the app.

Although participants were encouraged to sketch or draw their design ideas for app features, just about all participants who participated elected to write out their ideas to ensure clarity. A refinement of this method to support sketching ideas might include providing participants with interface templates that make it easier to envision what the foundation of the interface may look like. Alternatively, participants could be provided with components of an interface in paper form that they could modify and rearrange to fit their ideas. Even without participants not sketching their ideas and concepts, valuable information was gained through the co-design approach and aided in establishing guidelines and recommendations for future health and fitness technologies.

### Contributions to Design

While co-design and participatory design methods are well established in the field of design, this study presented a unique contribution to the format of co-design as a method. Conducting co-design sessions with older adults that also participated in the randomized controlled study proved to be a positive benefit for the brainstorming and ideation process. Participants were able to draw inspiration from their own challenges and successes during the use of their assigned app, and speak more directly about the needs of a health and fitness app for the older adult population. Being that participants had insight into the functionality and purpose of these apps for an extended period of time, participants were able to introduce relevant features and components and elaborate on why things did or did not work for their activity performance.

Another contribution to the overall method of co-design was the structure of the ideation sessions. With participants prompted to engage in individual brainstorming before coming to the larger group, participants were able to ensure feedback from their own experiences was incorporated into the larger group discussion. Future research efforts can look at the differences among co-design activities conducted with participants who have not had exposure to a technology of interest versus those who have as this may help to better quantify the effect of technology exposure to co-design.

## **CHAPTER 9: GENERAL DISCUSSION**

### **Insights from Study 1 and Study 2**

One of the more interesting insights identified early in this dissertation research was the way in which physical activity was defined by the older adult participants of both Study 1 and Study 2. Participants felt that the category of vigorous physical activity should be expanded for individuals as they age due to the fact that more simpler tasks are seen as physically demanding in older age. Findings from Study 1 suggest that technologies that track and encourage household activities or recreational and organizational hobbies might prove more useful to older adults. In examining the effect of health and fitness apps, breaking down activity levels by intensity helps us to get a better understanding of the impact of mobile fitness app interventions on the types of activities older adults engage in. Among those participants that reported a decrease in physical activity in one domain of intensity they reported an increase in another, suggesting that the impact of their app may have been less on a linear progress of one area of activity but a progression from lighter intensity activities to more moderate or vigorous intensity activities.

#### Older Adults' Engagement with Mobile Fitness Apps

Study 1 identified that older adults' engagement in physical activity is determined by a number of factors including social support from family and friends, access to facilities, individual confidence in the capacity to perform an activity, individual goal setting for the activity being performed, and the appeal of the activity itself (enjoyment, level of difficulty, ability to do it with others). Based on these findings, mobile fitness apps were selected to



represent both social and goal support to examine effectiveness of these strategies on physical activity behaviors. Although findings from this study did not statistically confirm my original hypothesis that social influence would be the most effective in improving physical activity levels, these findings did provide valuable insights stemming from data trends and qualitative group interview data. Participants reported that app use brought about a general awareness that increased physical activity without sustained durations of use of the app. Higher averages of app use did not necessarily correlate to higher increases in physical activity. These increases in physical activity were seen across the overall sample regardless of group and regardless of frequency of app use. While ratings of app motivation indicated that most participants felt their app was only somewhat motivational to the increase in their physical activity, just having something to track and report behavior encouraged them to want to be more active. Thus, more app use does not necessarily indicate the success of health and fitness apps as an intervention to health-related behaviors. Designing health and fitness apps for consistent and frequent use may not be the goal if using the app once or twice a week increases physical activity. Instead, designers may want to determine the features and components that make interactions more meaningful such that individuals are encouraged to change a behavior and interact with the app at a pace and frequency that feels less demanding. Among each group there were participants that reported doing more exercise than they would have normally done due to just knowing they had the app, as well as the app consistently making them think about their physical health where they might not have before.

Results from the semi-longitudinal comparative study provided other insights regarding older adults' use of health and fitness apps and the strategies which these apps are based on. As a larger insight group interviews identified that the use of stand-alone apps is less conducive than wearable trackers. Although stand-alone apps bring awareness and have the potential to provide beneficial health-related information related to physical activity, consistent use of mobile phones was considered cumbersome and hard to keep up with by older adults. These interview discussions also identified that although older adults do not feel that being connected to strangers is encouragement for physical activity, mobile health and fitness apps that facilitate in-person social connection may have more of an impact. Participants commented that activities such as walking in public spaces encouraged maintenance of physical activity because of the natural social connection that resulted from this activity.

Regarding goal support and activity progress, participants expressed that showing negative progress would only be relevant for individuals who aren't already motivated to be active. For those who are motivated but may not necessarily meet their set goals, seeing negative progress may be a deterrence to sustaining engagement. This suggests that there is value in examining motivational design strategies by the stage of behavior change that they are most relevant to. Apps should therefore be developed with feedback that is tailored not only to an individual's current performance but to the stage of change that most aligns with their overall history of activity. Future research could examine the validity of this assumption.

Lastly, in discussing ideal features for health and fitness apps, conversations quickly shifted to the benefit of these systems being a holistic assessment of overall health. Participants suggested the tracking and assessment of other factors outside of physical activity such as sleep patterns, hydration and water intake, and pain levels. Additionally, health vitals such as blood pressure and heart rate, were discussed as things that should be reported in a health and fitness app. Designing health and fitness apps with this approach may be more promote these apps as being more useful to older adults and thus help to encourage sustained use. Although knowing their physical activity history was seen as beneficial, a majority of participants expressed the desire to want to use something that is more inclusive to their overall health status and that would be supportive of interactions with medical professionals.

#### Effect of Behavior Change Strategies Among Older Adults

Despite my hypothesis that social influence as a motivational design strategy would be most effective in increasing physical activity behaviors among older adults, there was no significant difference found among physical activity data to support this claim.

Based on previous literature and findings from Study 1 indicating social influence as a key motivator of physical activity, I hypothesized that the mobile fitness app that leveraged social influence would see the most improvement in participants' physical activity levels and would also be the app that would see the most sustained use. By looking at participants that continued to use their assigned fitness app throughout the entire 10-week study, I was able to identify a trend between physical activity levels at baseline and those reported at the final follow-up assessment. It is also important to note that among the

*tracking+social* group, most participants reported not using the social networking or social feed features, and among the overall sample this behavior change technique was rated fairly low on the scale of motivational factors.

Older adults seemed most concerned with knowing their overall health status and if their current activity levels had surpassed previous levels. Supported by both quantitative and qualitative data, I identified that goal support has more relevance to improving physical activity levels and sustaining engagement with fitness apps, and that social influence through fitness apps though may present as a benefit when connecting older adults to those that they know and trust, is not a direct motivator to either of these behaviors.

### **Addressing the Research Questions**

The first research question and aim were concerned with identifying key motivators and facilitators to beginning and maintaining levels of physical activity as expressed by older adults. I hypothesized that social influence is a key motivating factor to addressing the physical activity behavior change needs of older adults. Findings from the semi-structured qualitative interviews conducted in Study 1 suggest that the key motivating factors associated with older adults' physical activity behaviors include both intrinsic and extrinsic factors such as the perceived enjoyment of the activity, social influence from friends and family, an understanding of the resulting health benefits of being physically active, and seeing printed materials and advertisements. While the aspect of social influence mirrors findings from previous research studies assessing these constructs, I was able to identify an emphasis on less studied determinants of physical activity among older adults such as known health benefits and satisfaction and enjoyment with the activity.

Additionally, by addressing these constructs in the phases of initiating and sustaining physical activity I have identified key strategies that align with two very important stages of behavior change, preparation and maintenance.

The second research question was concerned with the ability of key motivating factors identified in Study 1 to inform motivational design strategies and behavior change techniques relevant to the design of health and fitness technologies inclusive of the needs of older adults. This question was addressed by the evaluation of existing behavior change taxonomies and frameworks as well as the analysis of existing mobile health and fitness apps as discussed in Chapters 5 and 6. From this review and analysis, I was able to identify that although existing taxonomies and frameworks establish a useful foundation of techniques important to successful behavior change technologies, they lack techniques that speak to the determinants of older adults' physical activity behaviors. Thus, I have identified and proposed additional techniques and overarching motivational design strategies that are positioned to be more inclusive of older adults' needs. From the analysis of existing mobile health and fitness apps I determined that many existing apps primarily leverage *tangibly measure progress* and *depict link between physical activity performance and health outcome*, and few implement techniques such as *demonstration of behavior* or *assessing satisfaction* that may lead to successful behavior change.

Research question 3 focused on determining the effect of social influence and goal support as motivational strategies in mobile health and fitness apps on older adults' physical activity behaviors and sustained use of an app. I hypothesized that mobile health and fitness apps that foster social influence would demonstrate the largest increase in

consistent physical activity compared to those that foster goal support as measured by increased minutes of daily activity over baseline performance. Findings from Study 2 (See Chapter 7) suggest a trend of a larger increase in physical activity among participants in the *tracking+social* group that continued to use their app from baseline to final follow-up. Although my results did not indicate a statistically significant difference between the *tracking* and *tracking+goal* groups in minutes of physical activity at final follow-up, results do suggest a trend towards more of an increase among participants in the *tracking* group that sustained use of their fitness app.

Research question 4 aimed to identify the factors that lead to use or nonuse of a mobile health and fitness app. I hypothesized that both factors of perceived usefulness (effectiveness of the app meeting user needs) and perceived ease-of-use (how easy the app is to learn to use) would contribute to the use or non-use of health and fitness apps, and that behavior change techniques that support social influence and goal support will be considered most motivational. In regard to which factors would contribute to the sustained engagement with mobile health and fitness apps, I hypothesized that apps that leverage inclusive and universal design principles will be more usable and thus will see more sustained use. Findings from the semi-longitudinal study indicated that whether or not an app was effective in motivating a user to be active, as well as the perceived difficulty of the app were among the most relevant factors to app use. Additionally, apps that were found to be more usable did see more sustained and longer app use. These findings reject the hypothesis that there would be more of an impact of social influence as a motivational design strategy.

The fifth research question was not guided by a hypothesis, but instead was an exploratory question regarding the most ideal features and components of health and fitness apps as perceived by older adults. This exploration saw benefit in having the participant sample interact with existing apps for an extended period of time prior to a co-design session where participants were able to collaborate and collectively brainstorm ideal features. Among the many features that emerged from these sessions, there was common mention of things like speech-enabled interfaces, additional health metrics, and more robust reminders or alarms. Identifying these features through co-design helps to focus the efforts of designers in the space of mobile health technologies and better align the needs of the user and the criteria of future products.

### **Research Limitations & Future Directions**

Results of this study should be interpreted in the context of several key limitations. First, the selection of the experimental conditions was limited to apps that were present in both the iTunes and Android stores. Future studies may consider including all apps found in either of these platforms. Another limiting factor to determining effect and interaction between variables is the testing of a smaller sample size. With three experimental conditions, I would have ideally enrolled between 20-22 participants per group. Smaller initial enrollment and attrition left less than 12 participants per group, making it harder to detect smaller effects in the results of the comparative study.

Another limitation of this research was identified in the data collected in Study 2 in that app use and physical activity levels reports were collected by subjective self-report. For the three apps used there was no non-invasive way to collect participant app use that

would accurately reflect minutes of app use where the user may not be logging activity. While there are wearables devices that aim to accurately track physical activity levels, it was not the intention of this study to introduce older adults who were not familiar with wearable activity trackers to this method of activity tracking, nor did I want this to be an intended influence on the physical activity levels themselves. While physical activity levels were tracked by the apps assigned, app reports may not reflect actual activity due to users reporting to forget to turn the app on or stop the app from tracking after they were no longer active. Thus, users were asked to keep track of physical activity minutes on a daily and weekly basis and report at each follow-up assessment. Future research might incorporate wearable trackers that could assess physical activity performance during use and non-use of a mobile health and fitness app. An additional research objective may be to compare self-report of physical activity and physical activity as tracked by wearable trackers.

Based on the factors and refined behavior change techniques identified, it would be advantageous of future studies to test a prototype of a health and fitness app that incorporated these components. Developing an app that featured more inclusive behavior change techniques and testing it among a larger sample of older adults would establish the effectiveness and relevance of these strategies and techniques.

Lastly, this dissertation research focused specifically on older adults that did not meet the basic recommended levels of physical activity as identified by the World Health Organization. Study 1 interviewed two groups of participants, frequent and infrequent exercisers, and with no difference found among the results of these two groups, Study 2 simply recruited individuals who were active less than the recommended standard. Despite



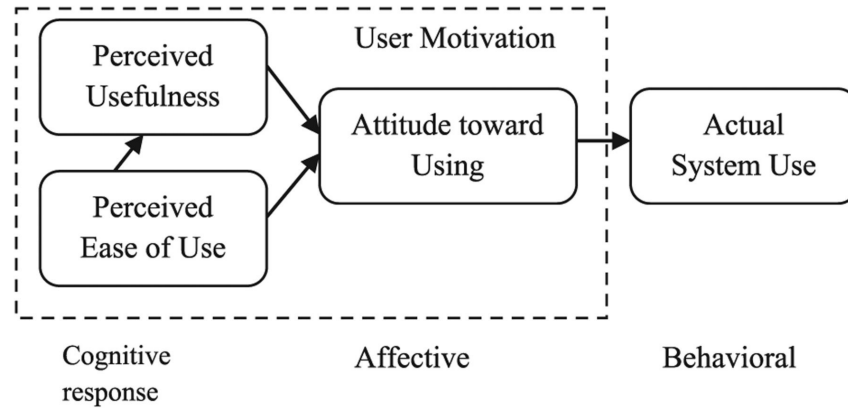
these limitations, this dissertation research contributes a thorough analysis and understanding of the factors that contribute to use or nonuse of health and fitness apps, as well as the effect that motivational design strategies have on older adults' physical activity behaviors. Future work could examine the difference among participants that are at different stages of behavior change as identified by the Transtheoretical Model of Behavior Change. This could include examining the difference in app use and engagement among individuals who are in the stage of pre-contemplation (identified the need and want to be physically active but may not have taken any steps to do so) and those who are in the maintenance phase (those who have just began a new physical activity regimen and are trying to maintain it).

### **Contributions to Methodology and Theory**

This study contributes to the field of design research in helping to standardize evidence-based design through empirically testing the effect of various design techniques and strategies. This study also highlights the importance of utilizing a mixed methodology approach in design research. Although quantitative data is useful to establishing effect as a result of an intervention, it is often not able to explain the effect of what works and does not work for certain users. It is also valuable to examine performance metrics in comparison with detailed feedback from participants to understand trends that may inform design. Additionally, in evaluating health and fitness apps through a semi-longitudinal field deployment we are better able to investigate natural use and interactions and understand how users are affected by app use in their everyday environment. Field testing aids in identifying a wide range of factors that contribute to overall system usability and

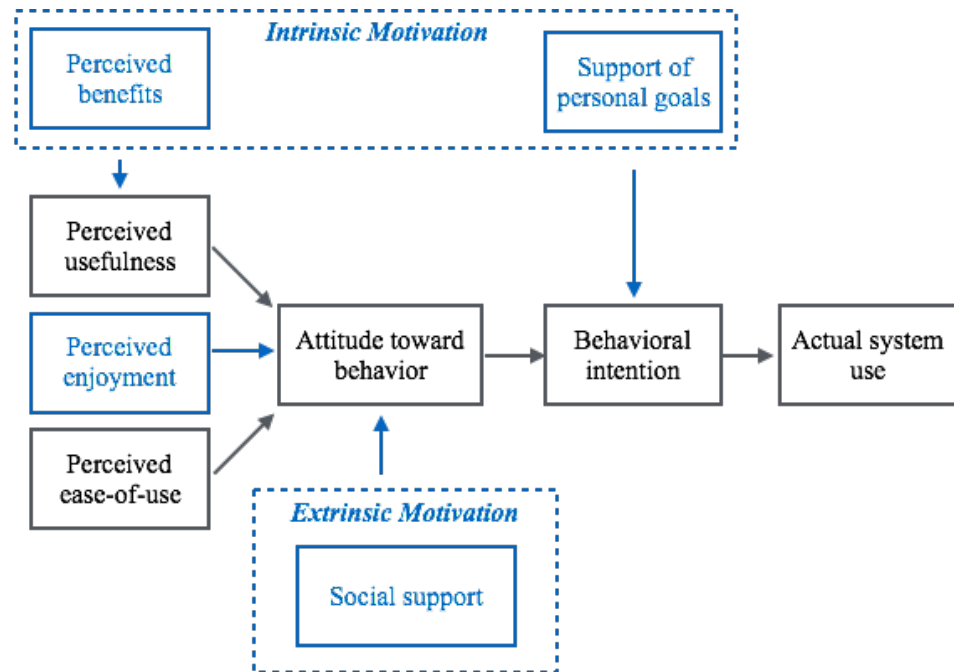
acceptance (Sun & May, 2013). By effectively identifying these important factors this study supports the use of field testing in design research and progresses design research from a field of understanding to one of testing and verifying.

Another important contribution of this work is the examination of usability as a factor to the adoption of mobile health technologies. To adequately evaluate the design of a mobile health and fitness app for potential success and adoption, it is appropriate to examine system usability. Although few if any research studies in the area of mobile apps for physical activity promotion have looked specifically at measures of usability and functionality as strategies to improve usage trajectory among users, these findings suggest that there is a direct correlation between the usability of an app and the sustained use it sees over time. Constructs derived from the TAM (Figure 18) suggest that both usability and functionality of apps play a major, if not the most important, role in the actual system use (Legris et al., 2003). Davis (1986, 1989) outlines in this model that both cognitive response of perceived ease-of-use and motivation lead to the actual use of a system; increasing or improving these measures should thus have a positive effect on use of the system. These constructs influence a user's attitude toward using a system, and have great implications for encouraging sustained engagement.



**Figure 18. Original Technology Acceptance Model**

Although the original TAM has seen many iterations (Holden & Karsh, 2010; Peek et al., 2014; Venkatesh et al., 2003), I propose additional variables that would lead to sustained system use among older adults. Results from the semi-longitudinal comparative study support previous research findings that perceived value or satisfaction with a technology are a key factor to system use (Chang et al., 2012). For mobile health technologies in specific there are important intrinsic and extrinsic variables that should also be considered as factors of system use. Based on both qualitative and quantitative results of Study 2, I propose that *Perceived benefits*, *Support of personal goals*, and *Social support* should also be variables included in a revised Technology Acceptance Model (Figure 19). Paired with proper integration of constructs from behavior change theory, these factors could have significant effect on the overall use of health and fitness apps and resultantly, the health benefits seen by the user.



**Figure 19. Technology Acceptance Model with additional variables**

## **CHAPTER 10: DESIGNING MOBILE HEALTH TECHNOLOGIES FOR OLDER ADULTS**

### **Inclusive Motivational Design Strategies and Technology Acceptance**

Existing taxonomies and frameworks propose several strategies and techniques as guidelines to creating technologies for health-related behavior change and have tested the effectiveness of these strategies and techniques on generally healthy young adults and adolescents. Research conducted in this dissertation identifies a more relevant and inclusive taxonomy of behavior change techniques to the health and fitness needs of older adults, and examines the effectiveness of their overarching strategies. While the primary objective of this study was to examine the effectiveness of these proposed strategies, I have also identified the factors that contribute to use and nonuse of these apps, as well as ways in which designers can develop apps that are more widely and consistently used.

Findings from Study 2 suggest that techniques that help a user to establish and work towards a tangible goal are most relevant to sustained use. Quantitative ratings of the importance of various behavior change techniques along with themes emerging from group interviews suggest that providing a user with a general awareness of their health status is more motivational and thus relevant to older adults initiating and maintaining activity. Thus, the implementation of goal support and health awareness in mobile health technologies would lead to more long-term adoption among older adults. Perceived benefits of these strategies were expressed to be not only a self-knowledge of progress, but the ability to communicate status and progress to healthcare professionals, which would be

convenient and support a more holistic approach to health and wellness. Although qualitative ratings indicate that the use of social influence is not relevant to older adults' health and physical activity behaviors, discussion of the topic suggest that this strategy should be refined and better implemented in an approach that would be more relevant to their social connection desires. The use of social feeds or alerts and notifications may not be relevant to older adults, instead social connection as a motivational design strategy should involve connecting older adults to other individuals that they are familiar with in a more peer to peer format as compared to attempting to connect to a larger network. Techniques associated with the adaptation strategy were determined to also be important to the perceived effectiveness and motivation of an app. Allowing users to set their own pace or identify new activities outside the scope of traditional exercise may have a direct correlation technology acceptance and sustained use.

Identifying relevant motivational design strategies for the development of mobile health technologies can greatly benefit the acceptance and adoption among older adults, as evidenced by the sustained use of deployed apps in this study. Participants rated social influence as a strategy as least important or effective to motivating physical activity, and trends in app use data suggest that the app leveraging this strategy also saw the earliest abandonment among participants.

### **Design Recommendations**

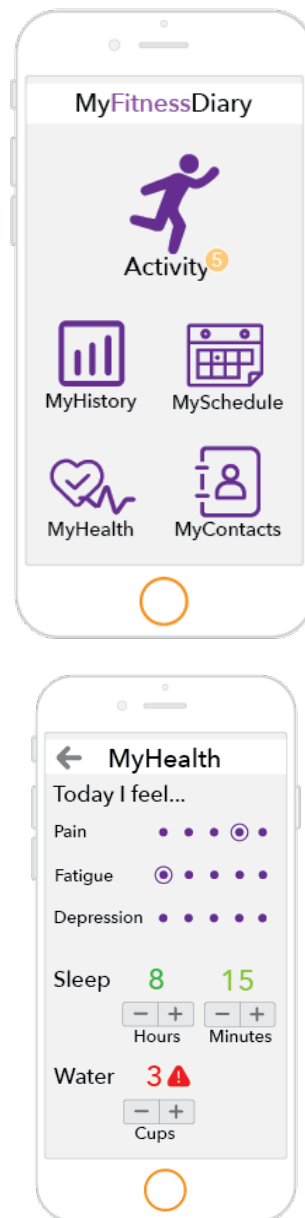
Based on the findings from this dissertation research I propose a number of design recommendations for future health and fitness apps that specifically target or are inclusive of older adults. These recommendations have the potential to inform successful mobile

health technologies among older adults, and broaden the scope of designers aiming to build meaningful products in the health and wellness domain. Although there is evidence base for these recommendations, I propose them as recommendations as opposed to guidelines or criteria since there is future work needed in this area to validate the effectiveness and relevance of the refined behavior change techniques and design strategies. These design recommendations can also be applied more generally to the design of technologies addressing health-related behavior change among older adults.

*Integrate comprehensive metrics of health and wellbeing*

Designers should consider the development of fitness and activity tracking apps for older adults as an opportunity to provide a holistic health assessment for potential users. Health management in older adulthood is a task that may be considered demanding and hard to accomplish without the help of reminders and organizational tools. Designing an app that collects data on other areas of health management outside of physical activity may prove more useful to older adults, resulting in increased and sustained use. From the comparative study, participants identified that tracking metrics such as sleep behaviors, hydration, blood pressure, heart rate, and other symptoms may be useful functionality when considering health and wellness. Although existing health apps cover an extensive set of individual health concerns and chronic illnesses (Dahlke & Ory, 2016), there are few if any that present a holistic assessment of user health data that might be relevant to older adults. As seen in Figure 20, allowing users to not only track health metric information but communicating feedback of this assessment in a holistic way (e.g. total health score or

comprehensive data visualization) can aggregate the vital sign readings that users have to keep up with and provide a one-stop record for older adults' health history.

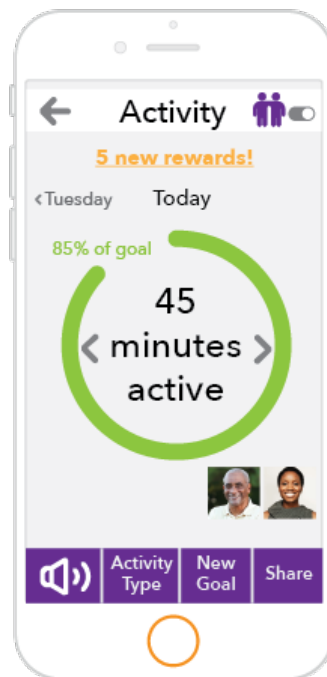


**Figure 20. Example interface for health and fitness app**



### *Leverage simplified feedback and reduce data entry*

One of the most important factors that emerged from this dissertation research was the association of app usability with duration and frequency of system use. While relevant, there is a need to go beyond universal design and accessibility principles, and consider other barriers to system adaptation for older adults. Apps that require long set-up times, extensive routines of data entry or that are otherwise confusing to older adults have been seen as inefficient, presenting a barrier to not only use of the app but negating motivation to be active (Kim et al., 2016; Kruse et al., 2016). Feedback and input of progress and status should take a more simplified form for health and fitness apps that target older adults.



**Figure 21. Simplified feedback of physical activity**

For example, a simplified way of notifying a user of their overall walking or hydration score could appear as a single number, combined with a color designation or icon to inform the user that this progress is on track or falls short of their goals as seen in Figure

21. Minimizing the number of screens that users have to go through to get to their history and progress can ultimately make for a better interaction experience, and reduce the amount of time a user spends trying to get to a desired feature. Although this may reduce the time a user is actually interacting with the app, time spent navigating through screens of useless information may be considered wasted and not a good indicator to designers and developers that their app is received well.

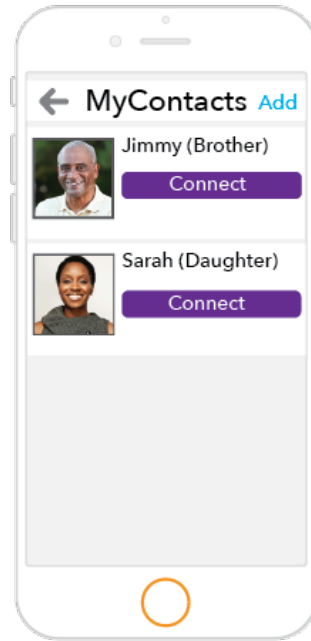
#### *Implement speech-enabled feedback and reminders*

To better meet the needs of older adults, health and fitness apps should rely less on the reading of small print and interpreting of graphs and charts. As such, these apps should utilize accessibility features that can provide universal access for older adult users aging with and without disabilities. As many older adults face impairments in areas such as vision or memory with increased age, alleviating the need to read small print or discern background design from functional button may improve the perceptions of the ease-of-use of these systems (Fisk et al., 2012). To anticipate the variable needs among the 65 and over population, health and fitness apps should incorporate alternative modes of feedback and reminders, such that the actual use of the app does not become a major barrier to physical activity promotion. For example, voice-activated feedback or auditory reminders would be an appropriate way for users to be notified of their progress or their upcoming schedule to engage in physical activity. Having this as a feature that can be turned on and off would allow a user to customize feedbacks and reminders based on their context of use, or their personal needs.

### *Implement social support on a personal level*

Health and fitness apps should leverage interpersonal connections between users and trusted family or friends. Currently, many health and fitness apps allow users to connect to their social network to share fitness progress, statuses, images, etc. As this form of social connection may not be relevant to adults over the age of 65 in regard to physical activity behaviors, it is necessary to refine the ways in which social connection is implemented in health technologies for this population. Supporting connection between older adults and their friends and family that are in other locations is an appropriate approach to the use of social support for the age demographic. The alleviation of social isolation is incorporated in the consideration of wellness among older adults (Martina & Stevens, 2006), thus may contribute to the support of an individual's overall health. Studies have proven that the basic concept of being connected to someone while being active has proven effective in encouraging physical activity behaviors (Beer et al., 2015; McAuley et al., 2000), and thus social support should be considered a viable approach to health behavior promotion.

A more effective approach to social support may be connecting individuals directly to another user of the app through video conferencing or messaging, allowing users to share their activity status, overall health progress, or engage in activity with someone else. See Figure 22.



**Figure 22. Social engagement in one-on-one approach**

*Frame performance suggestions around user-defined activities and goals*

Health and fitness apps that promote and support physical activity and health among older adults should allow older adult users to identify activities that are relevant to them or that they would like to engage in. Use of health and fitness apps may provide a novel opportunity for older adults to participate in activities they may not otherwise be aware of, and may also provide them with information about the health benefits of activities they normally engage in.

Supporting the progress towards user-specified goals should be a major objective of any health and fitness technology. Similar to the recommendation of user-defined activities, health and fitness apps should promote activities that fit a user's overall goals, as compared to activities that are deemed traditionally rigorous or have no justification for suggestion. Overall engagement with health and fitness technologies should be strategic

while enjoyable, thus algorithms that suggest convenient approaches to activities, types of activities, and level of activity should feed into a user's set goal for the day (or week, month). Apps should provide users with the option of identifying whether their goals are aligned to beating a certain performance metric, keeping a particular health vital at a certain level, weight management, or simple maintenance of activity. As an example, an app could feature a weekly calendar that encourages a user to designate the amount of activity they want to do and the intensity they feel comfortable performing at, and then suggest activities throughout the week that will help a user meet their goal of activity level.

These recommendations may also be useful to other forms of mobile health technologies in addition to mobile apps. Findings from Study 2 suggest that several participants felt that having a wearable component to track and provide feedback on their health and fitness would make it easier to have an item on them more consistently. Thus, another design direction might be to look at other ways to integrate glanceable displays that prompt activity and provide feedback that could be worn by the intended user.

## **Conclusion**

The emergence of mobile health and fitness apps has great potential value for the overall health and wellbeing of older adults, particularly by providing awareness of health and physical activity status. For these potential benefits to be realized, apps and other mobile health technologies must be designed in a way that is deemed accessible the technology proficiency of older adults and relevant to the factors that motivate their behaviors. Designers must face the challenge of developing technologies that are well accepted and consistently used by older adults, without introducing the burden of complex

interactions or systems that feature discouraging feedback. In order to establish this middle ground, this dissertation research sought to understand older adults' perceptions of mobile health and fitness apps, as well as the factors and system features that contributed to use and nonuse of health and fitness apps among older adults.

Analyzing initial findings from qualitative interviews along with examining the effectiveness and acceptance of existing health and fitness apps, I propose a refined, more inclusive set of behavior change techniques and motivational design strategies that better speak to physical activity behavior change among older adults. These techniques incorporate the needs of older adults to define their own pace and scope of activities, to establish tangible goals that they can be aware of, and to receive social support at a peer to peer level. Additionally, I have outlined design recommendations that are proposed to inform effective technologies for health-related behavior change.

Findings from this research potentially extend the constructs that are considered related to technology acceptance among older adults. Here I identified constructs that are not currently evident in existing models of technology acceptance, based on a better understanding of the factors of use as expressed by a sample of older adults. Although future work is needed to establish validity of these techniques with a larger sample of older adults, this work contributes to the space of designing mobile health technologies for behavior change, with significance not only to the field of design but to public health and psychology. This work will be useful to both aging research and design as a general discipline, and will help to expand the ways in which researchers and designers approach developing and evaluating mobile health technologies for older adults.

## APPENDIX A. STUDY 1 INTERVIEW GUIDE

Icebreaker:

- 1) Before we get to specifics, let's talk about your daily routine.
  - a. Can you tell me about the types of activities you typically do on a weekday?  
Think about where you go or who you may interact with.
  - b. Can you tell me about the types of activities you typically do on a weekend?  
Think about where you go or who you may interact with.
- 2) Now, let's talk about exercise. Think about any activities in which your heart beats faster than usual for a certain period of time.
  - a. What type of exercise activities do you typically do? If they say they do not complete exercise activities, continue to #3
  - b. How frequently do you complete such activities?
  - c. Can you elaborate on when you do such activities?
  - d. What makes it easy for you to exercise?
  - e. What makes it difficult for you to exercise?
  - f. Think about if there are any outside influences on your exercise level. Do your friends or family influence the type of exercise activities you do?
- 3) Let's think about physical activity more generally now. Think about any activities that require you to physically move from one location to another.
  - a. What physical activities do you typically do?
  - b. How frequently do you do such activities?
  - c. Can you elaborate on when you do such activities (Ex: time of day, for how long, with someone else?) Do you do such activities with someone else?
  - d. What makes it easy for you to be physically active?
  - e. What makes it difficult for you to be physically active?
  - f. Think about if there are any outside influences on your exercise level. Do your friends or family influence the type of exercise activities you do?
  - g. Does the media influence the type of exercise activities you do? Think about potentially any celebrities, books, movies or magazines, for example.
- 4) Some people choose to set physical activity or exercise plans or goals. Have you ever set a goal like this in the past few years?
  - If Yes –
    - a. IF multiple goals: Can you talk about the goal that was most important to you, or that you remember most clearly?
    - b. Did you receive any feedback that helped you monitor your goal?
    - c. Do you currently have any physical activity or exercise goals?
    - d. Do you keep track of your exercise activities?
    - e. How do you keep track of your activities?
    - f. What about your goals have made them successful?
    - g. What about your goals have made them challenging?
  - If No –

- a. Have you heard about or are you familiar with physical activity or exercise goals? If so, what do you know about them? How do you know about them?
  - b. Do you have any plans to set an activity goal in the future?
- 5) Say, for example, that you could design an ideal physical activity or exercise program that would encourage you to be active.
  - a. Would you prefer an activity on your own or in a group?
- 6) Have you ever taken an exercise class before?
  - a. What did you like about it?
  - b. What did you not like about it?
  - c. What type of activity would it be? Why?
  - d. What time of the day would it be? Why?
  - e. What else would you want in an activity program?
- 7) Give them the exercise confidence survey [Read them the instructions] (5 minutes)
  - a. *For each question:* Tell me what you were thinking when you responded that way. How did that affect your decision to engage or not engage in exercise?



## **APPENDIX B. CODING SPECIFICATIONS (STUDY 1 ANALYSIS)**

### Definitions

- Before Engaging in Physical Activity: things that are experienced prior to engaging in physical activity or prior to starting a new activity
- During Physical Activity Engagement: things experienced while exercising or being active
- After Engaging in Physical Activity: things experienced after participant is no longer exercising or being active
- Barriers: a circumstance or obstacle that prevents engagement
- Motivators: a person or influence that encourages a behavior of engagement
- Facilitators: something that serves as a support of an action or behavior

### Coding Specifications

- Before Engaging in Physical Activity
  - Perceived benefits to physical activity: anything the participant mentions as a positive perception regarding being physically active or exercising  
Ex: I know working out is good for my heart; working out helps to relieve depression
  - Internal motivators to become physically active or exercise: self-driven motivators that cause a participant to want to start or initially engage in physical activity or exercise  
Ex: I know that working out is good for me
  - External motivators to become physically active or exercise: outside motivators from family, media, etc. any influence that does not come from self  
Ex: my doctor encourages me to walk more; my daughter says I should start exercising
  - Environmental barriers to engaging in physical activity/exercise: anything that makes it hard or prevents the participant from getting started with physical activity/exercise that they would normally do or wish to do that they can't control; can be both general and specific  
Ex: weather, lack of facilities, can't walk outside because of neighborhood safety or hills/curbs
  - Personal barriers to engaging in physical activity/exercise: anything that makes it hard or keeps participant from engaging in physical activity/exercise that they

would normally do or wish to do; personal barriers relate more to things that participant could have control over; can be both general and specific

Ex: don't have enough time; I get lazy; not aware of what to do or where to do it

- Solutions/strategies to barriers: anything the participant uses to compensate for the barriers they encounter

Ex: if I can't work out due to weather I walk around indoors; hills are a problem so I use a walker or take a different route

- Types of goal set: participant states that there are specific things that they would like to do in reference to physical activity and exercise with a descriptor

Ex: I would like to walk more often; I try to swim 2-3 times a week

➤ During Physical Activity Engagement

- Facilitators to exercise/be physically active: things that help participant during the act of working out or being physically active

Ex: environmental supports, knowing the exercise, pace of activity/exercise, access to facilities, existing groups to do activity/exercise with

- Physical challenges experienced during physical activity/exercise: anything having to do with the body experienced while trying to complete physical activity or exercise

Ex: while trying to lift weights my arthritis bothers me; I usually can't walk long because of shortness of breath

- Solutions/strategies to physical challenges: ways in which the participant compensates for the physical challenges they experience

Ex: I stop often due to shortness of breath; I go at a slower pace so that my knees don't bother me

- External motivators to sustain physical activity or exercise: outside motivators to continue exercising or being physically active

Ex: I work out with SilverSneakers and they encourage us to keep coming back; my son takes me swimming every week

- Internal motivators to sustain physical activity or exercise: self-driven motivators to continue exercising once started

Ex: I walk every day so I don't let anything get in the way of that; I work out regularly to keep my weight down

- Types of physical activity: anything that requires a person to move from one place to another for extended time; moderate to heavy lifting in or outside the home; not traditional exercise

Ex: lift a wheelchair every day; I garden three times a week

- Types of exercise: any formal exercise activity done alone or in a group

Ex: aerobics class; chair class at the Y; walk a half a mile around my neighborhood

- After Engaging in Physical Activity
  - Ways progress is measured: ways that participant knows if they met their goal  
Ex: I know if I'm able to run longer; I measure my weight
  - Ways goals are tracked: ways that participants keep record of their exercise or physical activity behaviors  
Ex: I have a log that I write down how many times I work out
  - Physical challenges experienced after physical activity/exercise: anything having to do with the body experienced after physical activity or exercise is complete  
Ex: my arthritis sometime bothers me after I lift weights or walk for long periods of time
- Other: anything not covered in other codes but are interesting

## APPENDIX C. PROCEDURE (STUDY 2)

### Recruit Participants by Phone

- Use ppt Excel sheet for ppt info & update after call
- Check HFA calendar for availability
- Materials:
  - o 'Study 2 Participant Recruitment' Excel sheet
  - o Recruitment Phone Screening Script

### After Recruiting Participant

- Update 'Study 2 Participant Recruitment' Excel sheet
- Create Study Info sheet with date and time of participant study
- Mail scheduling packet with directions, parking pass, reminder letter, questionnaires
  - o Materials:
    - 'Study 2 Participant Recruitment' Excel sheet
    - Mailing packet
      - Scheduling letter (includes directions to HFA Lab/CATEA)
      - Parking Pass
      - Questionnaires:
        - o General Health and Demographics

### Day Before Study

- Make reminder call & update 'Study 2 Participant Recruitment' Excel sheet
  - o Materials:
    - 'Study 2 Participant Recruitment' Excel sheet

### Day of Study – Baseline Assessment

- **Informed Consent & Questionnaires**
  1. Greet ppt and provide completed parking pass (if applicable)
  2. Administer Informed Consent (have ppt sign 2 copies)
  3. Give ppt copy of each for their records
  4. Collect questionnaires from mailing packet (check for completeness)
  5. *If ppt did not bring questionnaires:* Fill out any missing forms
  6. Administer International Physical Activity Questionnaire (check for completeness)
  7. Administer Mobile Device Proficiency Questionnaire (check for completeness)
  8. Administer Experience with Mobile Fitness Apps (check for completeness)

9. Administer Perceptions of Mobile Fitness Apps (check for completeness)
10. Administer Physical Activity Self-Efficacy Scale (check for completeness)
- **Mobile Phone Download**
  11. Provide participant with mobile app download sheet
  12. Verify that app has been correctly downloaded and participant has signed in
  13. Collect participant email address
  14. Provide participant with study schedule and contact info
- **Debrief & Payment**
  15. Answer any questions
  16. Give ppt check and have them sign payment receipt
  17. Thank ppt for their time
- **End of session.**

### **Day of Study – Final Assessment**

- **Informed Consent & Questionnaires**
  1. Greet ppt and provide completed parking pass (if applicable)
  2. Inform participant of overview for session
  3. Administer International Physical Activity Questionnaire (check for completeness)
  4. Administer Physical Activity Self-Efficacy Scale (check for completeness)
  5. Administer Mobile Fitness App Use Questionnaire (check for completeness)
  6. Administer Opinions of a Mobile Fitness App (check for completeness)
  7. Administer Usability Evaluation of Mobile Fitness App (check for completeness)
  8. Co-Design Session With Participants
  9. Administer Motivations to Engage with a Mobile Health (check for completeness)
- **Debrief & Payment**
  1. Administer Debrief & answer any questions
  2. Give copy of debrief to ppt for their records
  3. Give ppt check and have them sign payment receipt
  4. Thank ppt for their time
- **End of session.**

### Materials:

- *Setup:*
  - Signs for doors indicating study in progress/include experimenter contact info (2)
- *Forms:*
  - ☐ Informed consent (2)
  - ☐ Extra copies of mailing questionnaires

- ☐ General Health and Demographics
- ☐ Scripts
  - ☐ Study Intro Script
- ☐ Baseline Questionnaires (administered individually)
  - ☐ International Physical Activity Questionnaire
  - ☐ Mobile Device Proficiency Questionnaire
  - ☐ Experience with Mobile Fitness Apps
  - ☐ Perceptions of Mobile Fitness Apps
  - ☐ Physical Activity Self-Efficacy Scale
- ☐ Final Questionnaires (administered individually)
  - ☐ International Physical Activity Questionnaire
  - ☐ Physical Activity Self-Efficacy Scale
  - ☐ Opinions of a Mobile Fitness App
  - ☐ Usability Evaluation of Mobile Fitness App
  - ☐ Motivations to Engage with a Mobile Health
- ☐ Debrief (2)

## **APPENDIX D. CONSENT FORM (STUDY 2)**

### **Georgia Institute of Technology**

**Project Title:** Evaluating the Effectiveness of Mobile Fitness Apps for Older Adults.

**Investigators:** Jon A. Sanford (Principal Investigator), Dr. Wendy A. Rogers (Co-Principal Investigator)

#### **Purpose**

You are being asked to be a volunteer in a research study. The purpose of this form is to tell you about the tasks required during the research study and to inform you of your rights as a research volunteer. Please ask any questions that you may have about this research study and any questions about tasks you will complete.

Thank you for your interest in this research study. Our work cannot be completed without your help. The purpose of this research study is to assess the effectiveness of mobile fitness apps for older adults. We expect to enroll 42 older adults in this research study.

#### **Exclusion/Inclusion Criteria**

Participants in this research study must be between the ages of 65 and 80. Participants must be fluent English speakers. They must be willing to perform light to moderate physical activities on their own. Participants must own a smartphone and have experience using mobile apps on their smartphone. Participants must not be currently using a mobile fitness app.

#### **Procedures**

If you decide to be in this research study, you will be asked to track your physical activity levels over the course of 10 weeks, during which time you will interact with an assigned mobile fitness app. You will be asked to complete periodic assessments to evaluate your use of the app and opinions of your interaction. We are interested in your experience interacting with the mobile app and how this affects your physical activity levels.

In an initial baseline assessment, you will be asked to provide information on your physical activity levels for the last 7 days. You will then be asked to complete a few questionnaires regarding your experience and perceptions of mobile fitness apps. Following this, you will be introduced to a mobile fitness app that you will be asked to interact with over the course of 10 weeks. You will be introduced to the mobile app and instructed on how to download it and begin using it. You will be asked to keep this app on your phone for the duration of

ten weeks. Follow-up assessments will be conducted via an online survey at the end of week 2, 5, and 8. At the final follow-up assessment, you will be asked to complete a few questionnaires about your overall experience. These surveys assess your opinions about the system you interacted with. Each survey should take no more than 10 minutes and the final follow-up session should last no more than 30 minutes to 1 hour. You may suspend participation in this research study at any time and for any reason. There is no penalty for suspending participation.

### **Risks/Discomforts**

The risks and discomfort from participating in this research study are no greater than those from daily household activities such as cleaning.

### **Benefits**

Participants are not likely to benefit in any way from participating in this research study. We hope that others will benefit from what we find about how mobile fitness apps can affect physical activity levels.

### **Compensation to You**

You will receive \$60 for participating in this research study. This depends on your participation with each follow-up assessment. You will make one visit to the Georgia Tech campus for the initial baseline assessment, and one visit for the final assessment. These visits will last approximately 1 hour. You will receive \$20 for the initial baseline assessment, \$10 for completing the online surveys, and \$30 for the final follow-up assessment.

U.S. Tax Law requires a set withholding of 30% for nonresident alien payments of any type. Your address and citizenship or visa status may be collected for compensation purposes only. This information will be shared only with the Georgia Tech department that issues compensation for your participation.

### **Confidentiality**

The following procedures will be followed to keep your personal information confidential.

All written data that is collected about you will be kept private to the extent allowed by law. To protect your privacy, written records will be kept under a code number. Your name will not be used. Your written records will be kept in locked files. Only research study staff will be able to access to these files. Your name and



other facts that point to you will not appear when the results of this research study are presented or published.

Audio files will be kept on a secure, password protected server that is only accessible to members of the research team. This data will be coded and your name will not be recorded with these files. Names will be stored separately from the data. These coded data will be housed in the Human Factors and Aging Laboratory within the School of Psychology in a password protected computer system within a locked office. Audio files will be deleted and destroyed once the study is over.

The Georgia Institute of Technology IRB will review research study records. This is to make sure that this research is being carried out properly. The Office of Human Research Protections may also look at research study records.

The National Institutes of Health/National Institute on Aging has the right to review research study records as well. They are the sponsors of this research study.

### **Costs to You**

There are no costs to you, other than your time, for participating in this research study.

### **In Case of Injury/Harm**

If you are injured as a result participating in this research study please contact Jon Sanford at (404) 894-1413 or Dr. Wendy A. Rogers at 404-894-6775. Neither the Georgia Institute of Technology nor the principle investigators have made provision for payment of costs associated with any injury resulting from your participation in this research study.

### **Participant Rights**

- Your participation in this research study is voluntary. You do not have to participate in this research study if you do not want to.
- You have the right to change your mind and end the research study at any time without giving any reason, and without penalty.
- Any new information that may make you change your mind about conducting this research test will be given to you.
- You will be given a copy of this consent form to keep.
- You do not waive any of your legal rights by signing this consent form.

**Questions about the Research Study**

If you have any questions about the research study, contact the investigators at 804-477-2147.

**Questions about Your Rights as a Research Participant**

If you have any questions about your rights as a research participant, you may contact Ms. Kelly Winn, Georgia Institute of Technology, Office of Research Integrity Assurance, at 404-385-2175.

**If you sign below, it means that you have read (or have had read to you) the information given in this consent form, and you would like to participate in this research study.**

_____	_____
<b>Print Name</b>	<b>Date</b>
_____	_____
<b>Participant Signature</b>	<b>Date</b>
_____	_____
<b>Signature of Person Obtaining Consent</b>	<b>Date</b>

We may use clips from audio recordings in research presentations to other academics and the public. Please, select **ONE** of the following options for use of recordings by initialing your preference below.

**Option 1:** If you are willing to allow us to use an audio recording of any portion of your interview, please initial here \_\_\_\_\_. If you have initialed here, we may use a portion of your interview in a presentation, for example. You will never be identified by name.

**Option 2:** If you would prefer that we use information from your audio recordings only in transcribed form (rather than as an audio clip), please initial here \_\_\_\_\_.

## **APPENDIX E. BASELINE QUESTIONNAIRES (STUDY 2)**

### **Background and Health Demographics Information Questionnaire**

**1. Gender:** Male ☐<sub>1</sub> Female ☐<sub>2</sub>

**2. Date of Birth:** \_\_\_\_ / \_\_\_\_ / \_\_\_\_

**3. What is your highest level of education?**

- ☐<sub>1</sub> No formal education
- ☐<sub>2</sub> Less than high school graduate
- ☐<sub>3</sub> High school graduate/GED
- ☐<sub>4</sub> Vocational training
- ☐<sub>5</sub> Some college/Associate's degree
- ☐<sub>6</sub> Bachelor's degree (BA, BS)
- ☐<sub>7</sub> Master's degree (or other post-graduate training)
- ☐<sub>8</sub> Doctoral degree (PhD, MD, EdD, DDS, JD, etc.)

**4. Current marital status (check one)**

- ☐<sub>1</sub> Single
- ☐<sub>2</sub> Married
- ☐<sub>3</sub> Separated
- ☐<sub>4</sub> Divorced
- ☐<sub>5</sub> Widowed
- ☐<sub>6</sub> Other (please specify) \_\_\_\_\_

**5. Do you consider yourself Hispanic or Latino?**

- ☐<sub>1</sub> Yes
- ☐<sub>2</sub> No

**5 a. If “Yes”, would you describe yourself:**

- ☐<sub>1</sub> Cuban  
☐<sub>2</sub> Mexican  
☐<sub>3</sub> Puerto Rican  
☐<sub>4</sub> Other (please specify) \_\_\_\_\_

**6. How would you describe your primary racial group?**

- ☐<sub>1</sub> No Primary Group  
☐<sub>2</sub> White Caucasian  
☐<sub>3</sub> Black/African American  
☐<sub>4</sub> Asian  
☐<sub>5</sub> American Indian/Alaska Native  
☐<sub>6</sub> Native Hawaiian/Pacific Islander  
☐<sub>7</sub> Multi-racial  
☐<sub>8</sub> Other (please specify) \_\_\_\_\_

**Health Information**

**1. In general, would you say your health is:**

- ☐<sub>1</sub> Poor      ☐<sub>2</sub> Fair      ☐<sub>3</sub> Good      ☐<sub>4</sub> Very good      ☐<sub>5</sub> Excellent

**2. Compared to other people your own age, would you say your health is:**

- ☐<sub>1</sub> Poor      ☐<sub>2</sub> Fair      ☐<sub>3</sub> Good      ☐<sub>4</sub> Very good      ☐<sub>5</sub> Excellent

**3. How satisfied are you with your present health?**

- ☐<sub>1</sub> Not at all satisfied      ☐<sub>2</sub> Not very satisfied      ☐<sub>3</sub> Neither satisfied nor dissatisfied      ☐<sub>4</sub> Somewhat satisfied      ☐<sub>5</sub> Extremely satisfied

**4. How often do health problems stand in the way of your doing the things you want to do?**

- ☐<sub>1</sub> Never      ☐<sub>2</sub> Seldom      ☐<sub>3</sub> Sometimes      ☐<sub>4</sub> Often      ☐<sub>5</sub>

5. The following items are about activities you might do during a typical day. Does your health now limit you in these activities? Check one box for each type of activity.

	Limited a lot <sub>1</sub>	Limited a little <sub>2</sub>	Not limited at all <sub>3</sub>
<b>a.</b> Bathing or dressing yourself			
<b>b.</b> Bending, kneeling, or stooping			
<b>c.</b> Climbing <b>one</b> flight of stairs			
<b>d.</b> Climbing <b>several</b> flights of stairs			
<b>e.</b> Lifting or carrying groceries			
<b>f. Moderate activities</b> , such as moving a table, pushing a vacuum cleaner, bowling, or playing golf			
<b>g. Vigorous activities</b> , such as running, lifting heavy objects, or participating in strenuous sports (e.g., swimming laps)			
<b>h.</b> Walking <b>more than a mile</b>			
<b>i.</b> Walking <b>one block</b>			
<b>j.</b> Walking <b>several blocks</b>			

**6. Please indicate if you have ever been told by a health professional that you have any of the following conditions. Check one box for each condition.**

Condition	Yes <sub>1</sub>	No <sub>2</sub>	Do not wish to answer/ Not sure <sub>3</sub>
<b>a.</b> Alzheimer's Disease			
<b>b.</b> Arthritis			
<b>c.</b> Asthma			
<b>d.</b> Cancer			
<b>e.</b> Cardiac Atrial Fibrillation/Cardiac Arrhythmia			
<b>f.</b> Chronic Kidney Disease			
<b>g.</b> Chronic Obstructive Pulmonary Disease (COPD)			
<b>h.</b> Coronary Artery Disease/Coronary Heart Disease			
<b>i.</b> Depression			
<b>j.</b> Diabetes/High Blood Sugar			
<b>k.</b> Heart Failure/Congestive Heart Failure			
<b>l.</b> High Blood Pressure/Hypertension			
<b>m.</b> High Cholesterol/Hyperlipidemia			
<b>n.</b> Osteoporosis			
<b>o.</b> Overweight			
<b>p.</b> Stroke/ Transient Ischemic Attack			

<b>q.</b> Other (If yes, please list below) <hr/>			
--	--	--	--

## International Physical Activity Questionnaire

We are interested in finding out about the frequency and duration with which you engage in physical activity. These questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about physical activities done for recreation, exercise, or sport.

Think about all the vigorous activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those activities that were done for **at least 10 minutes or more**.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities such as lifting heavy weights, aerobics, or fast bicycling?

\_\_\_\_\_ **days per week**

☐ No vigorous physical activities

**Skip to question 3**

2. How much time did you spend doing **vigorous** physical activity on one of those days?

\_\_\_\_\_ **hours per day**

\_\_\_\_\_ **minutes per day**

☐ Don't know/Not sure

Think about all the moderate activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that were done for **at least 10 minutes or more**.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities such as bicycling at a regular pace or doubles tennis?

\_\_\_\_\_ **days per week**

☐ No moderate physical activities

**Skip to question 5**



4. How much time did you spend doing **moderate** physical activity on one of those days?

\_\_\_\_\_ **hours per day**

\_\_\_\_\_ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. Here we are looking for walking specifically done for recreation, sport, exercise, or leisure.

5. During the last 7 days, on how many days did you **walk** for **at least 10 minutes or more at a time**?

\_\_\_\_\_ **days per week**

☐ No walking                      **Skip to question 7**

6. How much time did you usually spend **walking** on one of those days?

\_\_\_\_\_ **hours per day**

\_\_\_\_\_ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a week day?

\_\_\_\_\_ **hours per day**

\_\_\_\_\_ **minutes per day**

☐ Don't know/Not sure

## Experience with Mobile Fitness Apps Questionnaire

The purpose of this survey is to assess your level of familiarity and experience with smartphone applications for exercise and fitness. Describe your previous experience with mobile fitness applications by answering the following questions. Please read each question carefully and answer as accurately as possible. Your response to each question represents a critical aspect of this research, so please try to answer each question as best you can.

1. Have you EVER downloaded an 'app' on your phone or tablet to track your fitness? (tracking your exercise, steps, etc.)

No → Please skip to question 2.

Yes → Please answer items "a," "b," and "c" below.

- a. How long ago did you download this app?

☐<sub>1</sub> Three or more years ago

☐<sub>2</sub> 1-3 years ago

☐<sub>3</sub> 6-12 months ago

☐<sub>4</sub> 0-6 months ago

- b. How long did you keep this app on your phone or tablet?

☐<sub>1</sub> A year or more

☐<sub>2</sub> 6 months to a year

☐<sub>3</sub> 1 to 6 months

☐<sub>4</sub> Less than a month

- c. How frequently did you use this app while it was downloaded to your phone?

☐<sub>1</sub> 2 or more times a day

☐<sub>2</sub> about 1 time each day

☐<sub>3</sub> a few times each week

☐<sub>4</sub> less than once a week

☐<sub>5</sub> I never used it

**d. What were your reasons for using a mobile fitness app? Please select all that apply.**

- ☐<sub>1</sub> Incentivize me to exercise or be (more) physically active
- ☐<sub>2</sub> Track how much activity/exercise I was getting
- ☐<sub>3</sub> Weight loss
- ☐<sub>4</sub> Show/teach me exercises
- ☐<sub>5</sub> Help me relax
- ☐<sub>6</sub> Other reason \_\_\_\_ (fill in)

**e. How did you learn about the fitness app that you used?**

- ☐<sub>1</sub> Friends of family
- ☐<sub>2</sub> Searching the app store
- ☐<sub>3</sub> Web searches (e.g. Google)
- ☐<sub>4</sub> TV
- ☐<sub>5</sub> Doctor, nurse, or other medical professional
- ☐<sub>6</sub> Newspaper/magazine
- ☐<sub>7</sub> From other apps

**f. For what reasons did you discontinue use of the app? Check off all that apply**

- ☐<sub>1</sub> Didn't help me as I wanted
- ☐<sub>2</sub> Lost interest
- ☐<sub>3</sub> Took too much time to enter data
- ☐<sub>4</sub> Too confusing to use
- ☐<sub>5</sub> There were hidden costs
- ☐<sub>6</sub> No longer worked on my phone
- ☐<sub>7</sub> I no longer used it because I met my fitness goals
- ☐<sub>8</sub> I no longer used it because I stopped exercising
- ☐<sub>9</sub> I found a better app

**2. Please rate using 1, 2, and 3, the most important reasons you have not downloaded a fitness app.**

- ☐ Don't find them useful
- ☐ Wouldn't know how to use it
- ☐ Was not aware mobile fitness apps existed
- ☐ They aren't relevant to my age group
- ☐ I don't like tracking physical activity with technology
- ☐ They cost too much to buy
- ☐ My health is fine/I don't need one
- ☐ I don't trust letting apps collect my data

**3. Which of the following would you prefer in a mobile fitness app:**

- ☐<sub>1</sub> Fitness apps that had puzzles or obstacles
- ☐<sub>2</sub> Fitness apps that simulated sporting activities
- ☐<sub>3</sub> Fitness apps that showed me how to do an exercise
- ☐<sub>4</sub> Fitness app that showed me daily/weekly progress
- ☐<sub>5</sub> Fitness app that connected me to other people my age being active

## Perceptions of Mobile Fitness Apps Questionnaire

**The next set of questions will ask you about your perceptions of mobile fitness apps. This scale goes from “Strongly Disagree” to “Strongly Agree” with 7 response options. Please place an X in the appropriate response box.**

1. A fitness app that is fun would motivate me to be physically active.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

2. A fitness app that allowed me to see family and friends who are also engaging in physical activity would motivate me to be physically active.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

3. A fitness app that was customizable to fit my fitness needs would motivate me to be physically active.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

4. A fitness app that provided detailed instructions on fitness activities would motivate me to be physically active.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

5. A fitness app that provided information on the health benefits of being physically active (calories burned, blood pressure, heart rate, etc.) would motivate me to be physically active.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

6. A fitness app that informed me of my progress as I engaged with it would motivate me to be physically active.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

7. In order for me to continuously use a fitness app long-term it would need to be fun.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

8. In order for me to continuously use a fitness app long-term it would need to connect me to family and friends who are also engaging in physical activity.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

9. In order for me to continuously use a fitness app long-term it would need to be customizable to fit my fitness needs.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

10. In order for me to continuously use a fitness app long-term it would need to provide detailed instructions on the fitness activity I am being encouraged to do.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

11. In order for me to continuously use a fitness app long-term it would need to provide me with information of the health benefits of being physically active (calories burned, blood pressure, heart rate, etc.).

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

12. In order for me to continuously use a fitness app long-term it would need to inform me of my progress as I engaged with the app.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

**These questions ask about your opinions of the *potential usefulness* of mobile fitness apps.**

1. Using a mobile fitness app would improve my daily life.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

2. Using a mobile fitness app in my daily life would encourage me to be more physically active.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

3. Using a mobile fitness app would make it easier for me to be physically active.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

4. Interacting with a mobile fitness app would improve my ability to keep track of my health.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

5. I would use a mobile fitness app to be physically active.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

6. Using a mobile fitness app to be more physically active would benefit me at my age.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

7. Using a mobile fitness app would improve my overall health.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

## APPENDIX F. SAMPLE APP DOWNLOAD INSTRUCTIONS AND OVERVIEW GUIDE

### Endomondo - iPhone

Endomondo is a fitness tracker and personal training app that uses GPS to gather data on your physical activities. Just select an activity and the app will record data such as speed, duration, calories burned, etc. to give a complete summary of your workout.

1. Open App Store



2. Select the search icon on the bottom menu
3. Search for 'endomondo'
4. Scroll down to find the title "Running, Walking and Biking with Endomondo" and a green icon with a face that appears to be moving to the right



5. Select 'GET' next to the title of the app



6. Select 'Install'



7. Enter your Apple ID password and select 'buy' to complete the download of the application (This application is free)
  - For iPhone 6s and later models, you can also touch the home button to complete the download of the application
8. Once the app has been downloaded, click on 'OPEN', next to the title of the app, on the app store

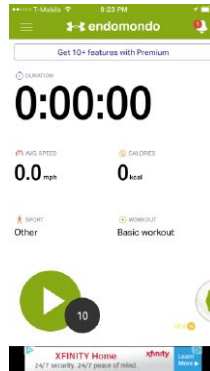
Please contact a member of the research staff if you feel you need help operating your app.  
Karan Jain - (404) - 948-8939 | karan26jain@gmail.com  
Christina Harrington - (804) - 477-2147 | cnh@gatech.edu



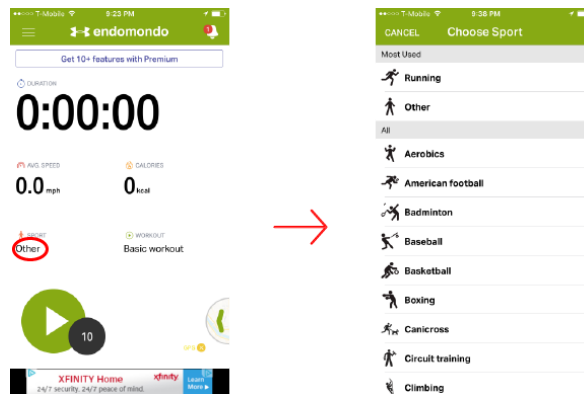
## Endomondo

This document is a brief guide on how to set up an activity, record data, and see data from your previous activities in the Endomondo application.

1. On opening the app, the home screen appears. You can add an activity and track data such as duration, speed, heart rate, calories burned, etc. on this screen.



2. To add an activity, click on the field marked in red on the home screen and select your activity from the list of sports.



3. To view your past activities, click on the menu icon on the top left of the home screen and select 'history' from the menu.

## APPENDIX G. FOLLOW-UP QUESTIONNAIRES (STUDY 2)

### Mobile Fitness App Use

**The purpose of this questionnaire is to assess your use with the mobile fitness app that you were assigned for this study. Please read each question carefully and answer as accurately as possible. Your response to each question represents a critical aspect of this research, so please try to answer each question as best you can.**

**1. Have you used the mobile fitness app that you were assigned in the last 7 days?**

- ☐<sub>1</sub> No → *Please skip to question 2.*  
☐<sub>2</sub> Yes

**a. If so, how many times in the last 7 days did you log into and use the app?**

- ☐<sub>1</sub> 2 or more times a day  
☐<sub>2</sub> about one time each day  
☐<sub>3</sub> a few (2-3) times each week  
☐<sub>4</sub> 1-2 times

**b. What is your primary reason for continuing to use this fitness app? Please check just one.**

- ☐<sub>1</sub> this app is fun to use  
☐<sub>2</sub> this app is useful in tracking my fitness  
☐<sub>3</sub> this app is easy to use  
☐<sub>4</sub> this app encourages me to be physically active  
☐<sub>5</sub> this app connects me to people that I know who are also being physically active  
☐<sub>6</sub> this app shows me progress towards my fitness goals  
☐<sub>7</sub> this app provides me information about the health benefits of being physically active  
☐<sub>8</sub> this app provides guidance on how to be physically active  
☐<sub>9</sub> this app customizes to my needs

**2. I plan to continue using this app.**

☐<sub>1</sub> No

☐<sub>2</sub> Yes

**3. This app encouraged me to connect to other people being physically active.**

☐<sub>1</sub> No

☐<sub>2</sub> Yes

**4. While using this app I connected to others being physically active face-to-face.**

☐<sub>1</sub> No

☐<sub>2</sub> Yes

**5. While using this app I connected to others being physically active through social media (Facebook, Twitter, other social platforms).**

☐<sub>1</sub> No

☐<sub>2</sub> Yes

**6. If you are no longer using the fitness app you were assigned, what are your reasons for not using it? Please select all that apply.**

☐<sub>1</sub> I have not been physically active to use it

☐<sub>2</sub> I don't find this app useful in tracking my fitness

☐<sub>3</sub> this app is difficult or confusing to use

☐<sub>4</sub> this app is not enjoyable to use

☐<sub>5</sub> I no longer need this app/I have met my fitness goals

☐<sub>6</sub> it takes too much time to enter data

☐<sub>7</sub> I don't carry around my phone frequently enough to use this app

☐<sub>8</sub> this app doesn't provide useful reminders

☐<sub>9</sub> this app does not track my non-exercise daily activities

☐<sub>10</sub> I have found another fitness app that better suits my needs

### **Opinions of Mobile Fitness App**

**This scale goes from “Strongly Disagree” to “Strongly Agree” with 7 response options. Please place an X in the appropriate response box.**

These questions ask about your opinions of the *usefulness* of the fitness app you used.

1. Using this fitness app improved my daily life.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

2. Using this fitness app encouraged me to be more physically active.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

3. Using this fitness app made it easier for me to be physically active.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

4. Interacting with this fitness app improved my ability to keep track of my health.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

5. Using a fitness app to be more physically active would benefit me at my age.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

6. I found this fitness app useful to my fitness needs.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

7. Interacting with this fitness app improved my overall health.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

8. Using this fitness app has increased my desire to be more active.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
----------------------------	----------------------------	----------------------------	----------------------------	----------------------------	----------------------------	----------------------------

Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree
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9. Using this fitness app has increased my level of physical activity.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

**These questions will ask about your *perceived satisfaction and enjoyment* with mobile fitness apps:**

1. I was satisfied with this fitness app.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

2. This fitness app was enjoyable to use.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

3. This app features an appropriate pace of interaction for me.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

4. Interaction with this app is consistent with my expectations.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

5. This fitness app could be improved by:

**These questions will ask about your *intent to use* a mobile fitness app:**

1. I would continue to use this fitness app to increase my physical activity.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

2. I would continue using this fitness app only if it was free to use.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

3. I would continue using this fitness app only if I had to pay to use it.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

4. I intend to continue to use this fitness app.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

5. I would be interested in using a fitness app to be physically active but not this one.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

## Usability Evaluation of Mobile Fitness App

**This scale goes from “Strongly Disagree” to “Strongly Agree” with 7 response options. Please place an X in the appropriate response box.**

1. This app provides alternate means of interaction such as speech input, hands-free, or eyes- free interaction.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

2. I am able to find the information I am looking for easily.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

3. The design of this app minimizes the occurrence of unintended actions (e.g., prompt messages, button placement, etc.).

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

4. This app provides informative feedback (e.g., a beep when pressing a key, an error message, etc.) that I am using it in the right way.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

5. I am able to tell that I have successfully completed an action in this app.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

6. This app provides different modes of feedback such as audio, tactile, or visual feedback.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

7. I can easily reverse my actions if I make a mistake in using this app.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

8. The design of this app appeals to me.

<input type="checkbox"/> <sub>1</sub>	<input type="checkbox"/> <sub>2</sub>	<input type="checkbox"/> <sub>3</sub>	<input type="checkbox"/> <sub>4</sub>	<input type="checkbox"/> <sub>5</sub>	<input type="checkbox"/> <sub>6</sub>	<input type="checkbox"/> <sub>7</sub>
Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree

9. The interface of this app is easy to understand and not complex.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

10. This app provides adequate contrast between background colors, images, and text.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

11. Fonts and images are legible in this app.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

12. Navigation in this app is easy - I can easily find my way from one screen to the next.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

13. I can easily understand the terms and language used throughout this app.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

14. I am able to change the size and brightness of the display in this app.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

15. The amount of physical force required to interact with this app is adequate.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

16. Buttons, keys, and icons are large enough for me to select without error.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree

17. I feel comfortable with this app regardless of my previous experience with mobile apps.

<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7
Strongly	Disagree	Somewhat	Neither	Somewhat	Agree	Strongly
Disagree		Disagree		Agree		Agree



## Motivations to Engage with Mobile Health/Fitness App

The following is a list of features found in mobile health/fitness apps. Keeping in mind your experience using a mobile health/fitness app, respond to each question (using the scale given), on the basis of how important this feature is for you.

- | 1                       | 2                     | 3         | 4                 | 5                      |
|-------------------------|-----------------------|-----------|-------------------|------------------------|
| Not at all<br>Important | Somewhat<br>Important | Important | Very<br>Important | Extremely<br>Important |
1. \_\_\_\_ Provides information of potential health benefits related to a health-related behavior
  2. \_\_\_\_ Depicts a link between my performance of a health-related behavior and the expected health outcome
  3. \_\_\_\_ Records my initial baseline health status
  4. \_\_\_\_ Provides me with information about recommended health-related behaviors
  5. \_\_\_\_ Allows me to learn how to do a health-related behavior from other people
  6. \_\_\_\_ Connects me to a community of people doing the same health-related behavior I'm doing
  7. \_\_\_\_ Provides endorsements for the behavior from medical and fitness professionals
  8. \_\_\_\_ Informs me that other people are doing the behavior
  9. \_\_\_\_ Provides instructional guidance on how to perform the health-related behavior
  10. \_\_\_\_ Demonstrates the health-related behavior through tutorials or videos
  11. \_\_\_\_ Allows me to rehearse the behavior before performing it
  12. \_\_\_\_ Provides suggestions of convenient approaches to the health-related behavior
  13. \_\_\_\_ Assesses my satisfaction with individual features through in-app ratings and feedback
  14. \_\_\_\_ Provides positive reinforcement for goal progress
  15. \_\_\_\_ Uses an incentive-based completion system
  16. \_\_\_\_ Visual images that are neutral or I can identify with
  17. \_\_\_\_ Tangibly measures my progress through steps, days, or other measures
  18. \_\_\_\_ Reviews my goals at times that I specify

19. \_\_\_\_\_ Prompts me to self-monitor a health-related behavior
20. \_\_\_\_\_ Reminds me to perform a certain behavior based on my behavior history
21. \_\_\_\_\_ Allows me to adjust the intensity level of the health-related behavior
22. \_\_\_\_\_ Provides alternatives to inputting my status
23. \_\_\_\_\_ Plans when and where I can perform the intended behavior
24. \_\_\_\_\_ Suggests new goals based on my progress and performance

## APPENDIX H. FINAL FOLLOW-UP INTERVIEW SCRIPT

### (STUDY 2)

#### Introduction

Welcome to our Focus Group session today. Thank you for coming in. My name is Christina, and today I will be asking you questions about your experience with mobile fitness apps. Your feedback will help us to better understand why people choose to use or not use mobile fitness apps, and to develop strategies to increase the use of health and fitness apps among older adults.

#### Procedure

First, I would like everyone to complete a few questionnaires. The questionnaires are in front of you and should take about 20 minutes to complete. For each of these, think about your recent physical activity behaviors and the fitness app that you used. Go ahead and begin and please let me know if you have any questions. <<*Hand over the following questionnaires*>>:

- International Physical Activity Questionnaire
- Self-Efficacy for Daily Physical Activity Questionnaire
- Mobile Fitness App Use
- Opinions of a Mobile Fitness App
- Usability Evaluation of a Mobile Fitness App

<<*After 25 minutes, collect questionnaires (be sure to write ID numbers on them) If anyone did not finish, tell them they will have time after the focus group to complete it.*>>

Next, we will discuss various aspects of fitness apps. We would like to hear about your real-life experiences regarding your use or non-use of health and fitness apps. We plan to take about 1.5 hours to discuss these topics. It is ok to get up during the session if you need to, but remember there will be an opportunity to take a 10-minute break halfway through the discussion.

#### Some rules for the conversation

We are really interested in your personal experiences and ideas.

If your ideas are different from someone else's: speak up, we are interested in a range of experiences.

You can follow-up on something that another person says as long as you do not interrupt that person.

Speak clearly and loudly enough for everyone to hear and for us to be able to transcribe the recording later.

Please speak one at a time (remember, we are *recording* the session, and we cannot understand the tape when more than one person is talking at a time).

A. Icebreaker/ warming up.

Let's start by going around the room and have everyone introduce themselves (first names only).

Great! Thank you for the introduction and welcome everyone. Now I will turn on the audio recorder and we will begin. <<*Turn on the recorder!*>>

I would like to start by asking you a few questions about mobile health and fitness apps. Here you can think about the one you were assigned or ones you have used in the past.

What are some of the things you like about mobile fitness apps?

What are some of the things you dislike?

What are your goals for using a health and fitness app? What are some of the things you'd be looking for the app to do?

Do you think there are activities that are easier to track with a health and fitness app? Like what?

What are some of the benefits to using health and fitness apps in your daily life?

Could you see health and fitness apps having benefit in other areas of your daily life? What areas would those be?

Would it be useful to have a health and fitness app that connects you to other people (friends and family) that are being active?

Would it be useful to have a health and fitness app that shows you both positive and negative progress?

What expectations do you have for future health and fitness apps?

Break (10 minutes)

Now we will take a 10-minute break. Feel free to stretch your legs or use the restroom. We will meet back here at (*name time*) to continue our discussion.

Welcome back. Next, I will be leading us through an ideation exercise where we will think about how we would design the ideal app for older adults. Here, I'd like you to imagine that you are creating an app to help you get active or track your current fitness. Remember there are no ideas too crazy or over the top.

Which features of an app are most useful to helping you be active?  
If you had to pick a top 3 features for the app what would they be?  
What type of features would help encourage you to continue using the app itself or make you interested in using an app?  
What are some of the features of health and fitness apps that you find are unnecessary?  
What are important things for designers to keep in mind when creating health and fitness apps that target older adults?

Now I would like you to complete one more questionnaire. This should take about 5 minutes. Go ahead and begin and let me know if you have any questions. <<*Hand over the following questionnaire*>>

Motivations to Engage with a Mobile Health and Fitness App

<<*If there is anyone who did not finish the previous questionnaires, allow them to do so now. Collect questionnaires once everyone has completed them (be sure to write ID numbers on them.)*

*Check that all answers have been marked on the questionnaires. If any answer is missing, check with the participant if they chose to not answer it or skipped it by accident. >>*

Thank you for participating today. Your opinions are very important to this research study.

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